COMMONWEALTH OF MASSACHUSETTS

DIVISION OF INSURANCE

HEARING TO FIX AND ESTABLISH 1988 PRIVATE PASSENGER AUTOMOBILE INSURANCE RATES

ADVISORY FILING

COMMONWEALTH OF MASSACHUSETTS

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Paul M. Stein
Debbie Thomson
Hilary Rowen
Assistant Attorneys General
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One Ashburton Place
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DATED: September 2, 1987

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RECOMMENDATIONS OF THE
ATTORNEY GENERAL
1988 PRIVATE PASSENGER AUTOMOBILE RATES

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1988
SUMMARY OF PROPOSED RATE CHANGES FROM FORM
100'S AND FORM 101'S

(1) COVERAGE	(2) 1986 EXPOSURE	(3) 1987 CURRENT AVERAGE RATE	(4) 1988 PROPOSED AVERAGE RATE	(5) PROPOSED CHANGE IN PREMIUM VOLUME	(6) PERCENTAGE CHANGE IN RATE
A-1, 10/20	3103795.00	71.37	81.70	32052202	14.5
A-2, PIP	3012233.00	20.73	22.95	6687157	10.7
B, 10/20	3103795.00	15.89	15.49	-1241518	-2.5
B, INCREASED LIMITS*	2312637.60	83.18	87.45	9874963	5.1
PDL, BASIC	3103795.00	125.26	130.75	17039835	4.4
PDL, INCREASED LIMITS**	2935705.30	9.49	9.98	1438496	5.2
COLLISION	1924902.90	212.47	212.53	115494	0.0
LIMITED COLLISION	169363.40	35.59	42.00	1085619	18.0
D, MEDICAL PAYMENTS	1426945.60	15.89	17.03	1626718	7.2
E, COMPREHENSIVE	2292033.00	99.32	92.40	-15860869	-7.0
U, 10/20	3103795.00	20.62	21.80	3662478	5.7
U, INCREASED LIMITS***	1212963.10	54.34	70.32	19383150	29.4
SUB. TRANSPORTATION	484361.00	31.00	32.00	484361	3.2
AVERAGE RATE		564.65	589.25		4.4

* 1986 AVERAGE RATE ASSUMES AN AVERAGE INCREASED LIMITS FACTOR OF .9533
1987 AVERAGE RATE ASSUMES AN AVERAGE INCREASED LIMITS FACTOR OF .8998

** 1986 AVERAGE RATE ASSUMES AN AVERAGE INCREASED LIMITS FACTOR OF .0783
1987 AVERAGE RATE ASSUMES AN AVERAGE INCREASED LIMITS FACTOR OF .0763

*** 1986 AVERAGE RATE ASSUMES AN AVERAGE INCREASED LIMITS FACTOR OF 2.6353
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ATTORNEY GENERAL RECOMMENDATIONS
1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
RATE COMPONENTS

	A-1	A-2	B	PDL	COLL	LMTD COLL	D	COMPRE-HENSIVE	U
(1) LOSS PURE PREMIUM (100A)	52.95	23.02	9.74	74.32	186.39	20.66	10.66	80.27	9.65
(2) LOSS DEVELOPMENT FACTOR (100B)	1.208	.726	1.208	1.134	.878	.566	1.079	1.029	1.875
(3) CLAIM COST TREND AND PROJECTION FACTOR (100C)	1.042	1.067	1.042	1.074	1.080	1.091	1.170	1.055	1.116
(4) CLAIM FREQUENCY TREND AND PROJECTION FACTOR (100D)	.988	.988	.988	.924	.999	.989	.988	.993	.988
(4A) SEAT BELT EFFECT	1.021	1.021	1.021	1.000	1.000	1.000	1.021	1.000	1.021
(5) CLAIM ADJUSTMENT EXPENSES FACTOR (100E)	1.105	1.105	1.105	1.098	1.122	1.122	1.105	1.122	1.105
(6) 1987 LOSS PURE PREMIUM TOTAL MARKET = (1)X(2)X(3)X(4)X(4A)X(5)	74.29	19.88	13.67	91.83	196.12	14.16	15.00	97.09	22.54
(7) COMPANY EXPENSE PURE PREMIUM									
(A) 1986 ADJUSTED ALLOWED PURE PREMIUM (100F)	6.74	1.70	1.23	12.72	19.88	5.84	1.40	11.21	1.04
(B) TREND TO 1987 (100G)	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028
(C) 1987 PURE PREMIUM = (A) X (B)	6.93	1.75	1.26	13.08	20.44	6.00	1.44	11.52	1.07
(8) COMMISSION EXPENSE PURE PREMIUM									
(A) 1986 ADJUSTED ALLOWED PURE PREMIUM (100F)	8.66	3.58	2.09	27.30	27.83	25.28	2.28	14.40	.45
(B) TREND TO 1987 (100G)	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028	1.028
(C) 1987 COMMISSION EXPENSE PURE PREMIUM=(A)X(B)	8.90	3.68	2.15	28.06	28.61	25.99	2.34	14.80	.46
(9) PREMIUM TAX	.023	.023	.023	.023	.023	.023	.023	.023	.023
(10) UNDERWRITING PROFIT PROVISION (100H)	-.126	-.126	-.126	-.040	-.022	-.022	-.126	-.022	-.127
(11) AVERAGE PREMIUM ((6) + (7C) + (8C))/(1.0 - ((9) + (10)))	81.70	22.95	15.49	130.75	245.42	46.20	17.03	123.53	21.80
(12) SYMBOL DRIFT ADJUSTMENT (100I)	0.000	0.000	0.000	0.000	-.134	-.091	0.000	-.252	0.000
(13) AVERAGE RATE (11) X (1 + (12))	81.70	22.95	15.49	130.75	212.53	42.00	17.03	92.40	21.80

002

1988 A.G.
Chang Affidavit-1

PREFILED TESTIMONY OF LENA CHANG

Q: Please state your name and occupation.

A: My name is Lena Chang. I am president of Chang & Company, Inc., an independent insurance and actuarial consulting firm located at 6 Beacon Street, Boston, Massachusetts 02108. I am appearing in this proceeding as the actuarial consultant of the Attorney General.

Q: Please describe your education and your relevant past employment.

A: My educational background includes an M.S. and a Ph.D. degree in mathematics from the University of Illinois. I was an Assistant Professor of Mathematics at the University of Illinois from 1965 to 1974. In 1974, I served as Assistant Dean of the School of Business Administration at Temple University. I was Visiting Associate Professor of Actuarial Science in the Department of Risk and Insurance at Temple University between 1974 and 1976.

From 1976 to 1979, I was an actuary-statistician in the State Rating Bureau of the Massachusetts Division of

Insurance. I established an independent consulting firm in 1979. During the past nine years the firm has been retained to perform actuarial and insurance analysis for a variety of public and private clients. The public sector clients have included the Massachusetts Attorney General; the Maine Public Advocate; the Rhode Island Department of Insurance; the New Jersey Public Advocate; the Delaware Department of Insurance; the South Carolina Consumer Advocate's Office; and the State Legislatures of Florida and Louisiana.

A copy of my current resume is attached to this testimony.

Q: Could you summarize your professional experience that is relevant to this proceeding?

A: I have previously participated in and presented expert testimony in numerous rate proceedings before the Massachusetts Division of Insurance including the following: private passenger automobile (1977, 1978, 1979, 1983, 1984, 1985, 1986, 1987) workers' compensation (1977, 1979, 1982, 1983, 1987); and Blue Cross/Blue Shield (1982, 1983, 1984, 1985, 1986). I have also participated in and presented expert testimony on automobile insurance,

workers' compensation, Blue Cross/Blue Shield and product liability insurance in rate proceedings conducted by a number of other states between 1979 and the present. My qualifications for presenting testimony on actuarial and statistical matters have been examined and accepted in formal rate proceedings before the insurance departments in eight states: Massachusetts, Maine, Rhode Island, New Jersey, Delaware, South Carolina, Texas and Minnesota.

Introduction

Q: Which parts of the Attorney General's advisory filing on 1988 automobile insurance rates did you prepare?

A: I am responsible for the preparation and presentation of Sections 100A, 100B, 100C, 100E, 100F, 100G, 101A, 101B and 101C. Those sections, with the accompanying narrative and supporting data, statistics, schedules and exhibits, constitute the Attorney General's recommendations with respect to the loss and expense provisions that should be used in fixing 1988 automobile insurance rates, and the reasons for those recommendations. To the best of my knowledge and belief, the data and calculations underlying these recommendations are complete and accurate.

Q: What procedure is observed in numbering the exhibits in the Attorney General's filing?

A: Basically, the numbering of the MARB filing exhibits has been followed. However, the numbering is significantly different in Sections 100C and 101A where the MARB deviated substantially from previously approved methodologies and where the Attorney General's methodology did not.

Q: What has been the basic approach of the Attorney General to this year's advisory filing?

A: In keeping with the general concern to streamline the hearing process and build on the extensive findings and determinations on data and ratemaking issues contained in past decisions, I have attempted so far as possible to remain consistent with recent approved methodologies of the Commissioner, especially those in the 1987 rate decision. This task has been complicated by the fact that the MARB's 1988 rate filing contains numerous explicit departures from such approved methodologies; in other instances where no inconsistencies have been expressly acknowledged by the MARB, it has nonetheless proved difficult -- on the basis of the information contained in the MARB filing -- to verify that methodologies previously approved by the Commissioner have been fully and accurately applied.

Finally, this year, the MARB filing contains a significant number of apparently unintentional clerical errors. I have corrected such errors in the Attorney General's filing.

Q: Did you consider whether previously approved methodologies of the Commissioner remain equally applicable to 1988 ratemaking?

A: Yes. In each case where I have used the previously approved methodologies, I have done so after determining that they remain suitable for 1988. In the few cases where they do not seem suitable or new evidence supports the use of an improved methodology, I have proposed the use of such alternative methodologies and have provided support for the recommendations.

<u>Loss Pure Premium and Related Data Base Issues</u>

Q: What are your concerns with respect to the data base submitted by the MARB which has been used as the basis for the MARB's filing this year?

A: This year, as last year, the MARB indicates that its reported pure premium base is inaccurate because of late reporting by a single carrier and that the data base must accordingly be adjusted to avoid inaccurate ratemaking results. The various adjustments carried out by the MARB impact overall rate indications because they affect the results obtained in Sections 100A, 100B and 100C of the Bureau filing. As a response to the Attorney General's data request, the MARB explained that the so-called late reporting of a delinquent carrier -- Travelers -- is apparently caused by the carrier's activity in updating its in-house processing system which delayed the reporting of claims.

Q: Was the MARB consistent in its use of adjusted data in all of the sections?

A: No, the MARB was not consistent in its adjustments to the data base. In Sections 100A and 100B MARB adjusted both the 1985 accident year first report and second report data and 1986 first report data for the delinquent carrier. However, in Section 100C-8, for the purpose of deriving internal quarterly data for trending purposes, the quarterly development data relating to accident year 1985 for bodily injury and property damage liability coverages

were unadjusted for the same delinquent carrier. This approach is inconsistent. Quarterly adjustments to the 1985 accident year data were provided in last year's Reference Code 21 of the MARB's data base. Therefore, for purposes of consistency, I have incorporated those quarterly adjustments in both the 1985 accident year claim cost and claim count data in deriving trend data in Section 100C.

Q: Did such adjustments produce different quarterly trend data from those calculated by the MARB in its Section 100C?

A: Yes. However, the numerical differences are slight. This is because the adjustment in claim cost was offset by similar adjustments in claim counts resulting in quarterly average claim cost trend data. I must stress that if a data adjustment is made in one section of the filing, the data should be consistently adjusted in other sections as a matter of principle. If consistent data adjustments are not employed throughout the filing, there is no assurance that the effects of various inconsistent treatments will cancel each other out.

Q: Do you have any specific comment on other data base adjustments made by the MARB in Section 100A - Reported Pure Premiums?

A: The MARB's calculations in Section 100A include an apparent clerical error for allocated loss adjustment expenses (ALAE) for the property damage liability coverage, where CAR facility data were used instead of total market data. The error is found in Line 3, Total Market, on page 13 of the 1988 MARB Filing and affects the calculation of PDL Basic Limits pure premiums in 1988 AG Exhibit 100A, page 3. The Attorney General's filing corrects that error. This correction changes the PDL-Basic Limits Pure Premium from the MARB's $74.10 to $74.32 as I have calculated it.

The MARB has also made an adjustment for catastrophic losses in the comprehensive coverage which it claims is consistent with a methodology proposed last year by the SRB and used by the Commissioner in setting 1987 rates. I have provisionally adopted this adjustment based on the MARB's representation, but the Attorney General reserves the right to modify his recommendation if analysis by the SRB shows that the methodology was incorrectly implemented.

So far as can be determined on the basis of available information, it appears that several other adjustments made in Section 100A were carried out consistently with the 1987 decision, and accordingly they have been adopted in the Attorney General's advisory filing.

Recognition of Per-Accident Limit Effect on Basic Limits Pure Premium

Q: Are any other adjustments made to the loss pure premiums in connection with your recommendations for Section 100A?

A: Yes. For Coverages A-1, B-Basic and U-Basic, I calculated the basic limits pure premiums recognizing the per-accident limit impact on the data base as reported in Reference 09. This adjustment is accomplished by employing the per-accident limit discount factor of .982 for basic limits losses calculated by the MARB and shown in the 1988 MARB filing page 605, for basic limits losses. In 1988 AG Exhibit 100A, pages 1, 2 and 4, line 2(b), this adjustment is applied. This changes the total market pure premiums for A-1 (10/20) coverage from the MARB's $53.87 to $52.95; for B-Basic coverage from $9.91 to $9.74; and for U-Basic coverage from $9.82 to $9.66 respectively.

Q: Why do you recommend these adjustments to the basic limits pure premiums?

A: In my opinion, the basic limits loss pure premiums for the bodily injury coverages as set forth in the 1988 MARB filing are overstated and produce excessive estimates for these coverages. The error arises from the MARB's use of a per-accident limit adjustment to increased limits data in Section 101 which the MARB introduced last year and which the Commissioner adopted in his Decision on 1987 rates. I have incorporated an adjustment to the proposed increased limits recommended this year to account for this per-accident limits effect, which is described in more detail later.

In this year's filing, it is recognized that adjustments for the per-accident limits effect must be consistently applied in the basic limits layer of losses used in Section 100A for determining basic limits loss pure premiums. In my opinion, the rationale for adjusting -- upward -- the increased limits data for the per-accident limits effect requires a corresponding adjustment -- downward -- to the basic limits layer of losses used in Section 100A for determining basic limits loss pure premiums.

It is internally inconsistent to apply the per accident limit adjustment to increased limits layers but not to adjust basic limits losses. If the Commissioner accepts the adjustments to the increased limits layers which the MARB recommends, the basic limits layer must also be adjusted to be consistent.

I agree, conceptually, that a per-accident effect occurs. Accordingly, I have applied a basic limits per-accident limit discount factor in Section 100A to A-1, B-Basic and U-coverages in a manner consistent with the Section 101A and Section 101C adjustments for this effect.

Claim Cost Development

Q: What do you recommend with respect to claim cost development as set forth in Section 100B of the Attorney General's filing?

A: Section 100B adopts the claim cost development factors which are calculated by the MARB according to the methodology accepted by the Commissioner last year. This approach is taken this year in the interest of narrowing the issues and in no way reflects a diminution of the concerns expressed by the Attorney General in prior year's

rate hearings regarding the exclusive use of incurred data to project ultimate expected losses for the long-tailed coverages. I continue to believe that the methods currently used to develop losses produce inaccurate estimates of ultimate claim costs.

A: Is there any new evidence of the probability for error in the use of the existing methodology for estimating claim development?

In recent years the Attorney General has consistently pointed out that the incurred loss data base relied on for loss development is inherently susceptible to the effects of insurer policy decisions taken for reasons not directly related to actual claim cost development. To the extent this may have occurred and the data are relied on without scrutiny or modification, inaccurate predictions of ultimate 1986 claim costs may occur. This in turn will generate inaccurate 1988 rates.

This year, in marked contrast to past experience, the latest diagonal of the liability coverages development factors (reflectinq the latest calendar year reserving policy) shows a consistently higher development for each accident year contributing to the latest diagonal.

Normally the observed pattern shows an up-and-down movement among the contributing accident years rather than a new diagonal that is uniformly higher than the previous one. I find this observation to be telling confirmation that claim reserves for past accident years have all been strengthened during the latest reporting calendar year.

The very strong implication of these data is that they are reflective not of actual claim cost development but rather of a policy decision to uniformly strengthen reserves for some reason extrinsic to the claim settlement process. One reason might be the importance of 1986 reserve levels in relation to the new tax treatment of insurers pursuant to the Federal Tax Reform Act of 1986. Under the new law, beginning in 1987 insurers will be able to obtain a tax offset only for discounted loss reserves using 1986 reserve levels as the pre-discounted base. This creates a tax-related incentive for the strengthening of reserves in 1986.

Moreover, the Commissioner's 1982 Massachusetts Workers' Compensation Decision notes at pages 37-38 that "it is widely reported that insurers recently have been strengthening reserves and that it [the traditional incurred development methodology] would result in an

over-estimate of ultimate claim costs." In my opinion the Commissioner's observation regarding Worker's Compensation is equally applicable to the longer tail coverages in automobile ratemaking where the incurred development approach is also strongly influenced by case reserves.

The Commissioner also noted in the 1987 Worker's Compensation decision at page 37:

> It is possible that the most appropriate loss development method combines the strong points of both the paid and the incurred methods. Paid loss development has the clear advantage of using those dollars actually paid by insurers, thereby eliminating much guesswork. But because paid losses at first report are a relatively small percentage of the losses that will ultimately be paid for a policy year, more importance must be placed on predicting future development. At best, this is a very difficult thing to do. On the other hand, incurred loss development minimizes the uncertainty of predicting future development but does this by accepting insurers' estimates of losses. It is generally accepted, however, that insurers' reserving practices change (insurers are sometimes strengthing and sometimes

weakening reserves), and insurers' could also simply misestimate ultimate losses.

... Alternatives to incurred losses should not be a last resort in the event of aberrant data. Rather, all methods should be analyzed to determine the one best able to blunt the effect of any significant industry-wide changes in reserving practices and accurately predict the future.

Due to the time restraints placed on the Attorney General this year, and in the interest of keeping to the allotted schedule, we have not yet fully evaluated this problem and are not specifically recommending the abandonment of the incurred two-year averaging method. However, I have compared the results of using a two year average and a three-year average and determined that the development factors for the liability coverages would change as reflected in the following chart:

	Two Year Incurred Average	Three Year Incurred Average
A-1, B-Basic	1.208	1.204
PDL	1.134	1.122
U-Basic	1.876	1.818

Q: What conclusions do you draw from this evidence?

A: In view of the substantial effect which a single year can have on development factors, I believe that it would not be unreasonable to use a three-year average rather than a two-year average to calculate development factors. While this change would not eliminate all of the problems which exist with incurred data, it would, at least, stabilize the effect of an occasional abberant diagonal such as the most recent diagonal for the liability coverages. This proposed change would be preferable to simply adopting the two-year average methodology.

More importantly, I recommend that the Commissioner review this matter carefully. If he determines that a more thorough study should be conducted, he should order the parties to submit a supplementary filing to address this specific issue. Even in the absence of a more detailed evaluation, it is my opinion that, based on the existing data, the development factors contained in the MARB filing represent exceptionally pessimistic estimates of the ultimate loss costs for the accident year 1986. This is due to the unusually high reserves established in 1986 for liability coverages across all accident years, and the serious impact of these data on development factors using a

two-year averaging technique. This, in turn, may mean that the use of these factors in making 1988 rates may produce very generous, if not excessive, estimates of the ultimate 1988 premiums.

Claim Cost Trend

Q: What are your recommendations regarding claim cost trending?

A: Section 100C of the Attorney General's filing follows the Commissioner's approved methodology for the past several years. The average claim cost trend is determined using both internal and external data indications with 1 and 2 piece ordinary least squares trending models, respectively. In my opinion these methodologies produce reasonable estimates of the trend in average claim costs which should be included in the 1988 rates.

Q: How did you calculate your average claim cost recommendations?

A: To calculate the average claim cost trend using the methodology approved in the last decision, I obtained all the updates of CPI indices from the United States Department of Labor and other relevant indices from other publishing bureaus. I then calculated all the external trend factors and weighted them with the internal trends derived from the Massachusetts Statistical Plan data in the same manner as approved in the 1987 rate decision in order to arrive at the recommendation on average claim cost trend in Section 100C.

I note that three specific sets of calculations for determining internal data are different from the MARB's calculations. These are:

(1) In AG Section 100C-8, the quarterly development data reflect adjustments for both accident year 1985 and 1986 late reporting by the delinquent carrier whereas the MARB's Section 100C-8 data were adjusted for the 1986 accident year but not for the 1985 accident year.

(2) In Section 100C-4, consistent with the Commissioner's 1987 Decision, I adopted the use of a 50/100 limits trend to adjust for "no-limits" trend

for B.I. coverage on page 4, Section 100C-4. I disagree with the MARB's renewed proposal to use a 25/50 trend for this purpose.

(3) In Section 100C-4, I used a slightly different deseasonalization methodology from the MARB's X-11 program. As has been proven in prior hearings, the trend data adjusted for seasonality by these two methods do not produce significantly different internal trend factors. This is done for technical convenience and I have no objection to the use of the X-11 methodology.

Average Accident Date

Q: What is the average accident date used for calculating claim cost trend in Section 100C?

A: I recommend the use of November 1, 1988 as a reasonable estimate of the average accident date.

Q: How do you arrive at your estimate of the average accident date?

A: I have calculated an average effective date using a linear trend of "first differences" based on the most recent five points of historical data. This produces an estimated average effective date of May 2nd. The reasonableness of this estimate is confirmed by fitting a power curve to the data. Each of these functions fit the data exceedingly well, and reflect a tapering off of the year-to-year changes in the average effective date. This effect had begun to emerge in the last few years and is now clearly confirmed by the 1986 data. The movement of the average effective date is attributed essentially to the historical shift from what had been a uniform January 1st policy renewal date to a staggered policy effective date system beginning ten years ago. Each year, the further shifts in the distribution of policy effective dates due to new policies issued, cancellations and so forth have an incrementally smaller impact on movement of the average date beyond January 1st. Eventually, these changes, for all intents, tend to cancel each other and the average effective date will stabilize. Because of this phenomenon, the changes in the average effective date will eventually approach zero. In my opinion, the linear trend of "first differences" relied upon by the Attorney General in his filing best captures the relevant ongoing phenomena and best reflects the future trend in effective dates.

Q: How does this method differ from the methods used in the past years?

A: The linear trend of "first differences" was one of several methods which have been selected in past years to estimte the average effective date. Last year, the MARB recommended an average effective date using the average indication from several methods, including linear "first differences", rounded to the nearest half-month. That approach produced the same recommended rounded date that would have been produced if a single linear curve of "first differences" had been selected. In my opinion, the fact that the Attorney General has not objected to the MARB's method in the past should not deter the Commissioner from considering this recommendation this year. Commissioner Hiam noted in this Decision on the 1985 rates (1985 Decision, pp. 14-15), that he was reluctant to face the question when it made no difference in the result. However, he specifically noted that alternative methods for projecting the average effective date should be reviewed by the parties for possible reconsideration at a future time. In my opinion, the three years of additional data since the 1985 Decision represent significant new evidence which confirm the necessity to reconsider the method for

projecting the average effective date. Moreover, this year is the first time in which the method of selecting this date does make a difference in the length of the selected projection period for trending. Also, for the first time, it does impact the estimates of a reasonable profits allowance.

In view of all of these factors, it is simply not reasonable to use a single straight linear projection from the historical data as the MARB proposes for selecting the average effective date. The MARB, does not offer any explanation in its Filing why it has abandoned last year's approach in favor of a straight linear trend.

Q: How do you derive the average accident date from the average effective date?

A: In the past, the simplifying assumption has been made that the average accident date is exactly six months after average effective date, rounded to the nearest half-month. The Attorney General's filing follows this approach and treats November 1st as the average accident date for purposes of trending.

Expenses

Q: What methods did you apply in the expense calculations in Sections 100E (claim adjustment expenses), 100F (expense pure premium) and 100G (expense trend correction factor and expense trend)?

A: I have applied the methodologies previously approved by the Commissioner in performing the calculations contained within these sections. Specifically, I have followed the Commissiner's 1987 Decision in calculating claim adjustment expense factors in Section 100E. I have also followed the Commissioner's Decision in calculating the expense pure premiums in Section 100F. With the exception of my calculation of the optional coverage purchase pattern adjustment as discussed below, I have followed the Commissioner's Decision in calculating the expense trend and projection factors in Section 100G. In my opinion, these methods produce reasonable estimates of the expected company and commission expenses that should be allowed in the 1988 rates.

Q: What changes did you make to the Commissioner's methodology of expense calculation?

Another error of the MARB is found in a multiplication contained in Section 100G-1, line (1)(n) causing the MARB trend correction factor to be too high. I have also corrected that error.

Q: What productivity adjustment factors did you select?

A: I have provisionally applied the productivity methodology and factor as determined by the Commissioner for 1987 rates. However, the Attorney General reserves the right to modify this recommendation if further changes in that methodology are recommended by the SRB.

Increased Limits

Q: Please describe how you calculate increased limits for the bodily injury liability coverage in Section 101A.

A: I have recommended BI increased limits factors which have been calculated using the same basic method which has been accepted in the Commissioner's decisions since about 1976. The details of these calculations are set forth below and in the exhibits contained in Section 101A. In my opinion,

A: The major methodological change which I have proposed is with respect to the historical data period used to determine the optional coverage purchase pattern adjustment for the Physical Damage coverages. I recommend the use of four years of data for all physical damage coverages. In examining the data, it appears that the use of four year data produces the best balance of the recognition of observed trend reversal phenomenon, the consistency of historical periods used, and the soundness of statistical estimation criteria.

Q: What other comments do you have with respect to the MARB's expense calculations?

A: In preparing the expense calculations I discovered several apparent clerical errors in the MARB calculations and corrected them.

In its trend correction exhibit in Section 100G-2 the MARB introduced a line 5.5 which causes an inconsistent comparison of all historic trends without productivity factor effects with a trend which incorporates productivity. In the Attorney General's filing I have corrected this error.

this method is a reasonable approach to estimate BI increased limits rate needs for the 1988 policy year. I am not persuaded that there is any significant new evidence that justifies abandoning the established methodology.

Q: What do you recommend with regard to an adjustment for the per-accident limits effect on increased limits?

A: As noted earlier, I agree that conceptually it is reasonable to adjust the data to reflect the impact of per accident limits on layers of losses, provided that the appropriate adjustments are made both to increased limits and basic limits data. The implementation of the adjustment is complicated by the fact that the MARB's filing uses an entirely new methodology which the commissioner did not accept last year to calculate BI increased limits factors. Thus there is no definitive record from which to establish how to implement the per-accident limits effect in the context of the approved methodology. Accordingly, I have proposed what I believe to be the most reasonable way to implement the per-accident limits adjustment. This approach is consistent with the established methodology traditionally used by the Commissioner and the parties to estimate increased limits

rate needs in Section 101A and also provides the correspondingly appropriate and necessary adjustment to basic limits data in Section 100A.

In my opinion, the BI increased limits factors which are displayed in Section 101A of the Attorney General's filing represent reasonable estimates of the BI increased limits rate needs for policy year 1988.

Q: Can you explain how you calculated the per-accident limits adjustment?

A: The exact step by step description of the methodology and the corresponding calculations can be described as follows:

In implementing the incorporation of the per-accident limits impact, the MARB utilized accident limit discount (ALD) factors in its determination of the increased limits factor for BI coverages. I have adopted these factors in the calculation of increased limits factors for BI. However, to incorporate correctly the ALD factors listed in the MARB 101A-4, Exhibit 1 into the traditional method of determining increased limits, further calculations were necessary.

The discount percentages calculated in the MARB 101A-4, Exhibit 1 are derived from and applied to the cumulative losses up to and including a given limit value. A discount applicable only to a specific layer must be determined from these percentages for use in my increased limits calculations.

This was done by first determining the cumulative losses (1988 AG 101A-5, col. (4)) up to and including a given layer from the layer of losses listed in Schedule 101A-1, page 1, col. (3). The ALD factors (AG 101A-5, col. (5)), one minus the percentages calculated in the MARB 101A-4, Exhibit 1, were then applied to the cumulative losses to arrive at the adjusted cumulative losses (AG 101A-5, col. (6)). These adjusted cumulative losses were then separated into losses by layer (AG 101A-5, col. (7)). The ratio between the adjusted losses by layer and the unadjusted losses by layer represents the implied ALD for a given layer (AG 101A-5, col. (8)).

Q: Do you have any comments on relative to your calculation of increased limits for property damage liability coverage in Section 101B?

A: I have followed the Commissioner's approved methodology. I have also corrected an apparent clerical error contained in Section 101B of the MARB's filing at 1988 MARB, p. 614, line (6), col. (3). The number displayed at p. 614, line 6, column 3 should have been 83,137.8 instead of 831,378.8.

In my opinion, the PDL increased limits factors shown in Section 101B and 101E of the Attorney General's filing are reasonable estimates of the PDL increased limits rate needs for the 1988 policy year.

Q: Please describe your calculation of increased limits for U Coverage in Seotion 101C.

A: I have followed the method previously approved by the Commissioner and a ruling by the Hearing Officer in this year's proceeding that the 1984 diagonal development factors should be eliminated for purposes of this calculation. I believe that it has been adequately established in past ratemaking that the 1984 diagonal development is aberrant because of insurer reserving practices related to concerns about the possibility of "stacking" coverage. The latest available data confirm

that the 1984 development is out of line, and I believe its deletion is appropriate for 1988 ratemaking.

I have not adopted a proposal by the MARB to judgmentally modify the Section 101C, Line 9 data to purportedly distribute bodily injury excess losses not only to the second layer, but also to all higher layers of U Coverage. This proposal is a change to the prior methodology and does not appear adequately justified. There is no apparent direct relationship between these loss layers and the BI losses transferred in. Furthermore, the MARB's factors for distributing the losses to the various layers are apparently totally judgmental, and unsupported by evidence. The MARB uses factors .30, .25, .20, .15, and .10 to judgmentally spread the losses to upper limits. Nowhere does the filing justify these adjustments.

Q: Do you propose any changes in the U coverage increased limits development procedure this year?

A: Yes. I recommend that the U coverage adjustment factor for per-accident limit impacts be the same as that calculated for bodily injury liability increased limits in Section 101A. This recommendation is made to be consistent with

the methods used to derive BI basic and increased limits rates. The calculations relating to Section 101C for appropriate layer adjustments for per-accident limit impacts for U coverage are displayed in 1988 AG 101C-4.

Q: Does this change result in higher recommended U coverage increased limits factors?

A: Yes, they are higher than would be the case under the Commissioner's previously approved methodology without this modification. In the meantime, the change also results in a correspondingly lower U coverage basic limits rate with respect to U coverage basic limits pure premiums, as pointed out earlier in this testimony in connection with the discussion of Section 100A. So long as the recommended per-accident limits effect adjustment is made to the basic limits "U" layer, the overall recommended level for increased limits factors on "U" coverages will produce reasonable estimates of the rate level needs for this coverage in the 1988 policy year.

Q: After reviewing the data, do you have any other comments on the U coverage increased limits calculation?

A: I continue to believe that "U" coverage data, in general, and "U" excess limits data in particular are too judgmental to be credible for rate making purposes. Because "U" coverage is essentially an extension of BI coverage, it would be preferable to use the BI data for making "U" coverage rates. While the Attorney General does not press this point in the interest of streamlining the hearing this year, I believe that at a minimum, the reasonableness of "U" coverage rates should be tested against the results using BI data. Those tests have shown consistently that the "U" rates produce extremely generous, if not excessive, premium allowances.

Q: Do you have any other comments regarding your calculation of increased limits factors?

A: As usual, the claim cost and frequency trend factors for the appropriate coverages are different from the MARB's factors due to the carried forward differences between the two filings in Sections 100C and 100D.

Second, I adopt the MARB's class mix adjustments as well as its methodology of distributing allocated claim adjustment expenses by limits purchased.

Miscellaneous

Q: What recommendations do you make with respect to the Age/Symbol Drift Adjustment (Section 100I), calculation of Current Average Rates (Section 100J) and substitute transportation, towing and labor (section 101)?

A: I adopt the MARB's calculations of these matters insofar as they appear consistent with the methodologies in prior decisions and do not appear unreasonable. The Attorney General does not take any position in this filing as to the adoption of model year rating. I have used the age/symbol adjustment factors calculated in the traditional matter.

Signed under the pains and penalties of perjury this 2nd day of September 1987.

Lena Chang

Dr. Lena Chang

NARRATIVE HIGHLIGHTS OF DR. CHANG'S RESUME

Dr. Chang has worked with numerous local, state and federal agencies and with a variety of private clients. A list of assignments performed for our clients is provided in the accompanying resume.

Dr. Chang is licensed by the Commissioner of Insurance of the Commonwealth of Massachusetts as an Insurance Advisor in all lines of insurance including Life, Health, and Property and Liability. She is also a qualified actuarial scientist whose credentials and ability to provide sound actuarial analysis and recommendations have been carefully scrutinized during the many regulatory and legislative proceedings in the various states where her services have been retained. She has been accepted as an expert actuarial witness in formal rate hearings conducted by or on behalf of the following public agencies:

Massachusetts Department of Insurance
New Jersey Department of Insurance
New Jersey Board of Public Utilities
Rhode Island Department of Insurance
Minnesota Department of Insurance
Texas Department of Insurance
South Carolina Department of Insurance
Delaware Department of Insurance

The accompanying resume provides brief descriptions of the various professional activities and publications undertaken by her since her insurance career began some 10 years ago. The following is a narrative highlight of Dr. Chang's experience.

From 1974 to 1976, Dr. Chang was on the faculty of Temple University in Philadelphia, Pennsylvania and taught various graduate courses in the Actuarial Science Program of the Department of Risk and Insurance. These courses included Life Contingencies, Demography, Compound Interest Theory, Statistics and Numerical Analysis -- course materials which encompass the Society of Actuaries' curriculum material for the first five exams.

In 1976, Dr. Chang joined the State Rating Bureau of the Division of Insurance, Commonwealth of Massachusetts, as one of the special six-member actuary-statistician team under then Commissioner James M. Stone. Dr. Chang assisted Commissioner Stone in the computer implementation of a completely reformed classification rate structure for automobile insurance. She was in charge of workers' compensation insurance issues and assisted the Commissioner in numerous other actuarial tasks.

Since 1979, as a private independent consultant, Dr. Chang has been actively involved in workers' compensation and no-fault automobile insurance legislative reform efforts in several states. In the area of workers' compensation, Dr. Chang assisted the Florida House Committee on Insurance in the formulation of its 1979 reform act -- the nation's first "wage loss" system in which a return to the basic concept of compensating essentially for "actual" loss of earning is stressed. She provided pertinent cost impact estimates for various proposals before the committee and critiqued the estimation techniques of the National Council on Compensation Insurance (NCCI). In 1982, Dr. Chang performed similar tasks for the Louisiana Governor, Speaker and relevant Senate and House Committees. She was the first outside, out-of-state consultant contracted by the House of Representatives in the history of Louisiana. She was the first consultant in its history invited to address the Representatives in their Chamber. Since 1984, she has also costed several major proposed revisions in the Massachusetts workers' compensation law.

In Rhode Island, Dr. Chang was retained by the Director of the Department of Business Regulation to assist the Governor in the implementation of the new workers' compensation law. She is currently involved in helping Rhode Island's new Division of Workers' Compensation become established within the Department of Business Regulation for the purpose of monitoring the competitive rating law. She is also assisting with the statistical design of ratemaking data collection on the Division's new computer system. In addition, she has also advised the Department of the cost impacts of the 1982 workers' compensation reform legislation and has presented expert testimony concerning the NCCI's 1984 rate level filing.

In 1984, Dr. Chang also served as expert consultant to the Public Advocate in the State of Maine in its review of legislative reform proposals as well as the NCCI's rate level filing in that state. In Hawaii, Dr. Chang was a member of a team of experts who were retained to do a study for the legislators in their attempts to reach a consensus on the reform of the Hawaii system.

In the area of automobile insurance legislation, Dr. Chang assisted in the Florida Committee on Insurance in evaluating the various proposed changes in the auto no-fault structure. She is currently assisting the Department of the Public Advocate in New Jersey in evaluating the rate revisions submitted by the companies to comply with the various reform bills recently enacted.

In summary, the independence of Dr. Chang's background and experience has provided the legislators in several states with a clear view of the issues before them without having to filter out the factor of "where she is coming from", i.e., which interest group she represents. In the records of all the legislative hearings during which Dr. Chang testified or participated, it is clear that the unbiased opinion of their own expert helped the legislators make their own choices with confidence.

Another major aspect of Dr. Chang's consulting work has been the conduct of expert actuarial reviews of numerous rate filings in workers' compensation, automobile, medical malpractice and products liability around the country.

In the field of health insurance, Dr. Chang has performed actuarial analyses and has given expert testimony on the Blue Cross/Blue Shield health insurance rate filing for the past three years as an actuarial consultant for the Massachusetts Attorney General's Office. She has also conducted actuarial evaluations of Blue Cross and Blue Shield rates for the Delaware Insurance Department and the Rhode Island Department of Business Regulation. In 1983, Dr. Chang was a member of a team of experts providing actuarial and cost evaluations of the health plans available to the city of Burlington, Vermont.

In 1984, Dr. Chang was retained by the New Jersey Department of the Public Advocate to provide expert actuarial testimony concerning the pension funding calculations in a rate petition submitted by the Board of Public Utilities by the New Jersey Bell Telephone Company. For this assignment Dr. Chang examined the actuarial methodologies used to value pension assets as well as the assumptions used to estimate pension investment expenses and to calculate long-term investment earnings of pension assets.

Dr. Chang and her staff give continual personal attention to their clients' general information requests. Through their contracts with the various states as well as with the Federal legislative and regulatory bodies, they constantly keep abreast of new developments, new concepts, new laws and new regulations in insurance. In turn, such information is made available to those for whom they consult. Their clients are free to call whenever they have questions or need information. Chang & Company also provides all computer services necessary for projects involving actuarial statistical and mathematical calculations. Chang & Company has, in addition, word-processing facilities for the production of reports and exhibits.

CIRRICULUM VITAE

Dr. Lena Chang

I. **Academic Degrees**:

Ph.D.	Mathematics	June, 1964 University of Illinois
M.S.	Mathematics	Jan., 1960, University of Illinois
B.S.	Physics	Sept., 1958 University of Illinois

II. **Academic Positions**:

Taught graduate and undergraduate courses in Mathematics and Actuarial Science, including: Modern Algebra, Linear Algebra, Advanced Calculus, Numerical Analysis, Mathematical Logic, Number Theory, Topology, Differential Equations, Group Theory, Group Representation Theory, Real Variables, Galois Theory, Theory of Finite Fields, Vector Analysis, Probability and Statistics, Compound Interest Theory, Life Contingencies and Mathematics of Life Insurance.

Temple University	Philadelphia, Pennsylvania
1974 - 1976	Visiting Associate Professor Actuarial Science Department of Insurance and Risk
1974 (Spring)	Assistant Dean, School of Business Administration
Trenton State College	Trenton, New Jersey
1973 - 1974	Adjunct Faculty, Department of Mathematics
Tsing-Hua University	Hsing-Chu, Taiwan
1970 (Spring)	Visiting Professor, Mathematics
University of Illinois	Chicago and Urbana
1965 - 1974	Assistant Professor Mathematics (Chicago)
1970 - 1971 (On Sabbatical)	Visiting Lecturer, Mathematics (Urbana)

1964 - 1965	Instructor, Mathematics (Urbana)
<u>Michigan State University</u>	East Lansing
1961 - 1962	Lecturer, Mathematics

III. <u>Professional History</u>:

<u>September, 1983</u>

Licensed All Lines (Life, Health & Accident, Property & Casualty) Insurance Advisor.

<u>February 1979 to present</u>:

Chang & Company, Inc., Boston, Independent Actuarial, Mathematical, Statistical and Insurance Consultants. Services include analysis of insurance rate filings, design and monitoring of data surveys, expert testimony at hearings, drafting of insurance legislation and general advice in respect to representative clients include:

A. <u>State and Public Organizations</u>:

State of Delaware Department of Insurance	1979 -	Analysis of Workers' Compensation rate filing submitted by the Delaware-Pennsylvania workers' compensation rating bureau.
	1984 -	Examined Blue Cross and Blue Shield cost and income data to determine amount to be returned to subscribers from special reserve account in connection with a disputed rate case that was remanded to the Department of Insurance by order of the court.
State of Florida Insurance Committee Commerce Committee House of Representatives	1979 -	Continuing.
	a.	Advised Committee prior to enactment of new 1979 Workers' Compensation law (the "wage loss" law). Costed impact of new law.
	b.	Designed data call and computer program for continued oversight monitoring of new law with annual analysis of effect of new law.

	c. Costed impact of 1981 Auto No-Fault Proposals.
	d. Legislative consultant for Products Liability, Medical Malpractice and other insurance matters.
State of Hawaii Legislative Auditors Office	1983 - Workers' Compensation Study with J. Haldi Associates.
State of Louisiana	a. Actuarial consultant to the Speaker of the House and the House Committee on Commerce and Labor Relations. Costed impact of 1982 H.B. 256 and its many amendments for Workers' Compensation.
	b. Addressed the 1982 House of Representatives in the House Chamber on the possible impact of the Proposed Workers' Compensation Legislation.
	c. Advised the Governor and the Senate Labor Committee on the costing of S.B. 14, The Workers' Compensation Reform Bill, which was enacted in January of 1983.
State of Maine Public Advocate	a. 1984 - Reviewed NCCI workers' compensation rate level filing and proposals for legislative reforms.
	b. 1986 - Reviewed and presented expert testimony on NCCI workers' compensation filing in response to statute requiring appropriate rate reductions in response to benefit changes.
Commonwealth of Massachusetts Department of the Attorney General	a. 1982 to present, annual Blue Cross-Blue Shield Medex rate hearings.
	b. 1982 Municipal Deferred Compensation Plan.
	c. 1983 to present, annual automobile rate hearings.
	d. Actuarial Analysis and Testimony for 1984 to present annual Blue Cross/Blue Shield Non-Group Rate Filings.

Minnesota Legislative Study Committee on Workers' Compensation State Fund		1980 - Presented seminar on general Workers' Compensation ratemaking procedures.
State of New Jersey Department of the Public Advocate		1979 - Continuing Automobile, Homeowners, Medical Malpractice and Products Liability insurance rate analysis and testimony. Loss Reserve and Investment Income studies. General actuarial consultant.
		1984 - Expert consultant and hearing witness on pension funding requests in rate petition submitted to Board of Public Utilities by Telephone Company.
		1986 - Expert consultant to analyze Blue Cross-Blue Shield proposed new combined product design for small group and non-group and medi-gap lines of insurance.
State of Rhode Island		
Office of the Attorney General		1979 Workers' Compensation rate hearing.
Department of Business Regulation, Department of Insurance		1982 - Continuing.
	a.	Consultant to the Governors' Committee on the implementation of the New Workers' Compensation Wage Loss Law.
	b.	Consultant to the Department of Business Regulation, Insurance Division on Workers' Compensation rate setting, self insurance regulation, competitive rating processes and other actuarial and statistical issues.
State of South Carolina, Department of Consumer Affairs	a.	1979 Automobile rate hearing.
	b.	1980 Workers' Compensation rate hearing.
	c.	1981, 1982 Evaluation of Workers' Compensation rate filing.

State of Vermont City of Burlington Ad-Hoc Committee on Health Benefits		1983 - Advisor to the Mayor with Larry Kirsch. Evaluation of the city's current health plan and review of the ratemaking data and process employed by its current carrier. Review alternatives available such as HMO's.

B. <u>Private Clients</u>

Associated Industries of Massachusetts		1979 - Continuing. Workers' Compensation rate hearings. Costing of proposed Massachusetts workers' compensation law reforms. Study for design of state Workers' Compensation self-insurance program and other actuarial consultation to members. Medical Malpractice reform legislation.
Construction Industries of Massachusetts, Inc.	a.	1981 - Continuing. Actuarial evaluation of the practical impact of the change to the unlimited payroll program. Hearings negotiations, etc.
With Associated Industries of Massachusetts	b.	1982 Workers' Compensation rate hearing. 1983 Workers' Compensation Law Amendment Hearings. 1985 law reform. 1986 law amendment filing.
Central Diagnostic Laboratory Tarzana, California		1986 - Statistical Analysis and expert testimony on the disputed Medi-Cal payment.
International Clinical Laboratories Randolph, Massachusetts		1983 - Statistical Analysis and expert testimony on the Medicare over-payment issue.
Minnesota Association of Commerce and Industry		1979 - 1980 Workers' Compensation rate hearing.
Texas Association of Business	a.	1980 Workers' Compensation rate hearing.

	b.	1980 hearing on unlimited payroll proposal. Data survey of probable cost to employers.
	c.	1981 hearings on investment income and law amendment factors.
	d.	Legislative drafting and advice on statistical reporting and rating laws.
With Texas Southwestern Barge Fleet Service, Inc.	e.	1982 Workers' Compensation rate hearing. Design of alternative insurance mechanism for member employers.
New Technology, Inc. Huntsville, Alabama		Evaluation of pension and profit sharing plans, and all casualty and property insurance.

C. <u>Professional Projects</u>

Insurance Workshop Series	Sponsored and taught at the 1980 Boston Workers' Compensation Workshop: "The ABC's of Ratemaking."
People's Insurance Company of China	Lectured on the American Insurance System, Peking, Canton, August, 1981.

<u>1976 - 1979</u>

At Massachusetts Division of Insurance. Member of State Rating Bureau. Developed new actuarial concepts for Automobile, Workers' Compensation, and Medical Malpractice. Expert Testimony at hearings. Advised Commissioner on new Merit Rating law, Annual Statement study and cost impact of filed or proposed rates. Designed and oversaw computer programs which determined cost to each policyholder under alternative proposals or changes in rating methodology. Published with other Bureau Members a study on Automobile Insurance Risk Classification.

<u>Pre-1976</u>

A. Insurance Consultant

Commonwealth of Pennsylvania Office of State Auditor General	Valuation of loss reserves for State Workmen's Insurance Fund. 1975 - 1976.

United States Department of Commerce	Evaluating effect of utilizing Workers' Compensation coverages for Product Liability Insurance 1975 - 1976.
United States Department of Labor	Costing of proposed benefit levels in Federal Employees' Compensation. 1975.
Gordon Associates Washington, D.C.	General insurance consulting. 1975 - 1976.
United States Senate Labor Committee	Consultant to United States General Accounting Office. Costing of proposed bill on Federal Minimum Standards for Workers' Compensation Law. 1974 (with Professor Gerald Hartman).

B. Research Scientist

Ford Motor Company Dearborn, Michigan	Scientific Laboratory, Ford Research Center. Mathematical adviser for research physicists. 1960 - 1961.

IV. Publications and Presentations

A. "The Discounted Loss Reserve Model and An Analysis of its Income Tax Offset Effect." Presented at the Annual Meeting of the American Risk and Insurance Association, Inc., Philadelphia, PA., August 1983.

B. "An Analysis of the New Jersey Formula for Including Investment Income in Property-Liability Insurance Ratemaking." Journal of Insurance Regulation, to appear (1983). Co-Author, J. David Cummins.

C. "Investment Income Considerations in Property/Casualty Insurance Ratemaking", Risk Theory Seminar, American Risk and Insurance Association. University of Pennsylvania, 1981.

D. "A Comparison of Ultimate Claim Cost Estimates in Financial Reporting and Pricing Decisions." American Risk and Insurance Association, Toronto, Canada, August, 1979. Co-Author, Andrew F. Giffin.

E. "Pricing Automobile Insurance under Multivariate Classification of Risks: Additive versus Multiplicative." Journal of Risk and Insurance, March 1979: Proceedings of August, 1978 Joint Statistical Association Conference, May, 1979. Co-Author, William B. Fairley.

F. "An Estimation Model for Multivariate Insurance Rate Classification." Automobile Insurance Risk Classification: Equity and Accuracy. Monograph: Division of Insurance, Commonwealth of Massachusetts, 1978. Co-Author, William B. Fairley.

G. "Application of New Theory and New Methods in Evaluation of Multiple Decremented, Multiple Life Functions to Various Aspects in Risk and Insurance Areas." Risk Theory Seminar, American Risk and Insurance Association. University of Indiana. 1976.

H. "Canonical Coin Changing and Greedy Solutions." Journal of Association of Computing Machinery, July, 1976. Co-Author, James Korsh.

I. "Reversionary Annuities as Applied to the Evaluation of Law Amendment Factors." Proceedings of the Actuarial Research Conference. Brown University, 1975.

J. "FECA Effective Study." Report to the Department of Labor Employment Standards Administration, 1975. Co-Author, Jerry Gordon.

K. "Sequence Covers and Maps." Proceedings of the 6th Southeastern Conference on Combinatorics, Graph Theory and Computing. Utilitas Mathematics, October, 1975. Co-Author A.T. Poe.

L. "Integral Representation of Non-Abelian Groups of Order pq." Michigan Mathematics Journal. July, 1965. (Doctoral Thesis).

V. Professional and Honor Societies:

1. American Mathematics Society

2. American Statistical Association

3. American Risk and Insurance Association (ARIA)

4. Risk Theory Seminar, ARIA

5. Phi Kappa Phi, National Scholastic Honorary Society

6. Sigma Xi, National Honorary Society for Research in Science

7. Pi Mu Epsilon, National Honorary Society in Mathematics

VI. Grants and Awards:

A. 1965 - 1968, National Science Foundation Research Grant (Group Theory)

B. 1962 - 1964, Office of Naval Research (Group Representation Theory)

C. 1956, Shi-Ai Award, University of Illinois - Scholarship Award to Outstanding Women Undergraduates

D. 1956 - 1958, Tuition Scholarship, University of Illinois

E. 1955, Dean's List, Fontbonne College, St. Louis, Missouri

VII. Organizations:

Principal: (1978 - 1980)	Chinese Language School Newton, Massachusetts
Member:	Board of Directors National Association of Chinese Language Schools
Member:	Boston Chinese Cultural Center Committee on Cultural and Educational Exchange
Member:	Association of Women Business Owners

VII. Personal:

Born: Yunnan, China

Language: Fluent Chinese

United States Citizen: 1964

Residence: Lexington, Massachusetts

Health: Excellent

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ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100A

REPORTED PURE PREMIUM

SUMMARY OF SCHEDULE 100A

Company .... Attorney General

Line of Business .. Private Passenger

Rates Effective ... January 1, 1988

Reported Pure Premium *

Coverage	Total Market	Adjusted Market
A-1 10/20 Limits (1988 AG 100A, p.1)	$52.95	$37.51
A-2	23.02	17.93
B, Basic 10/20 Limits (1988 AG 100A, p.2)	9.74	5.82
PDL, Basic (1988 AG 100A, p.3)	74.32	57.49
Collision $300 Deductible	186.39	140.80
Limited Collision $300 Deductible	20.66	17.31
D, Basic	10.66	7.53
E, Comprehensive	80.27	42.47
U 10/20 Limits (1988 AG 100A, p.4)	9.66	6.44

* All Reported Pure Premiums are from MARB 100A except those noted.

Determination of Loss Pure Premiums
A-1, 10/20 (Basic)

		(A) Total Market	(B) Voluntary Market	(C) Residual Market Deficit
1.	1986 Calendar Year Earned Exposure (Data Base Reference 01)	3,103,795	1,467,591	
2.	a. 1986 Accident Year Incurred Losses (Data Base Reference 09)	158,584,667	42,291,266	
	b. Accident Limit Discount Factor (1988 AG 101A-5, Basic Limit)	0.982	0.982	
	c. Adjusted Losses ((2a)*(2b))	155,730,143	41,530,023	
3.	1986 Accident Year Incurred Allocated Claim Expense			
	a. Total Reported (Data Base Reference 09)	12,939,278	4,427,685	
	b. Proportion Assigned to Basic Layer (1988 MARB 101A-3, page 2)	66.6%	66.6%	
	c. Ammount Assigned to Basic Layer	8,617,559	2,948,838	
4.	1986 Pure Premium ((2c)+(3c))/(1)	52.95	30.31	
5.	Adjustment of Voluntary Experience to Total Market Exposure Distribution (1988 MARB 100A-3, page 3)	xxx	0.8423	
6.	1986 Adjusted Pure Premium (4)/(5)	52.95	35.98	16.97 *
7.	Adjustment to Residual Market Deficit Due to Effects of SDIP (1988 MARB 100A-3, page 3)	xxx	xxx	0.9098
8.	Final 1986 Adjusted Pure Premium (6) * (7)	52.95	37.51 **	15.44

* (A)-(B)
** (A)-(C)

1988 AG
Exhibit 100A-1
Page 2

Determination of Loss Pure Premiums
B, Basic

	(A) Total Market	(B) Voluntary Market	(C) Residual Market Deficit
1. 1986 Calendar Year Earned Exposure (Data Base Reference 01)	3,103,795	1,467,591	
2. a. 1986 Accident Year Incurred Losses (Data Base Reference 09)	29,145,950	7,610,885	
b. Accident Limit Discount Factor (1988 AG 101A-5, Basic Limit)	0.982	0.982	
c. Adjusted Losses ((2a)*(2b))	28,621,323	7,473,889	
3. 1986 Accident Year Incurred Allocated Claim Expense			
a. Total Reported (Data Base Reference 09)	2,433,971	739,533	
b. Proportion Assigned to Basic Layer (1988 MARB 101A-3, page 2)	66.6%	66.6%	
c. Ammount Assigned to Basic Layer	1,621,025	492,529	
4. 1986 Pure Premium ((2c)+(3c))/(1)	9.74	5.43	
5. Adjustment of Voluntary Experience to Total Market Exposure Distribution (1988 MARB 100A-3, page 3)	xxx	1.0000	
6. 1986 Adjusted Pure Premium (4)/(5)	9.74	5.43	4.32 *
7. Adjustment to Residual Market Deficit Due to Effects of SDIP (1988 MARB 100A-3, page 3)	xxx	xxx	0.9098
8. Final 1986 Adjusted Pure Premium (6) * (7)	9.74	5.82 **	3.93

* (A)-(B)
** (A)-(C)

1988 AG
Exhibit 100A-1
Page 3

Determination of Loss Pure Premiums
PDL, Basic

		(A) Total Market	(B) Voluntary Market	(C) Residual Market Deficit
1.	1986 Calendar Year Earned Exposure (Data Base Reference 01)	3,103,795	1,467,591	
2.	1986 Accident Year Incurred Losses (Data Base Reference 09)	228,693,255	693,952,231	
3.	1986 Accident Year Incurred Allocated Claim Expense (Data Base Reference 09)	2,019,010 #	715,793	
4.	1986 Pure Premium ((2)+(3))/(1)	74.32	47.77	
5.	Adjustment of Voluntary Experience to Total Market Exposure Distribution (1988 MARB 100A-3, page 3)	xxx	0.8558	
6.	1986 Adjusted Pure Premium (4)/(5)	74.32	55.82	18.50 *
7.	Adjustment to Residual Market Deficit Due to Effects of SDIP (1988 MARB 100A-3, page 3)	xxx	xxx	0.9098
8.	Final 1986 Adjusted Pure Premium (6) * (7)	74.32	57.49 **	16.83

* (A)-(B)
** (A)-(C)
\# Correction of MARB.'s use of residual market figure.

Determination of Loss Pure Premiums
U, 10/20 Basic Limits

		(A) Total Market	(B) Voluntary Market	(C) Residual Market Deficit
1.	1986 Calendar Year Earned Exposure (Data Base Reference 01)	3,103,795	1,467,591	
2.	a. 1986 Accident Year Incurred Losses (Data Base Reference 09)	28,209,709	8,406,399	
	b. Accident Limit Discount Factor (1988 AG 101C-4, Basic Limits)	0.982	0.982	
	c. Adjusted Losses ((2a)*(2b))	27,701,934	8,255,084	
3.	1986 Accident Year Incurred Allocated Claim Expense (Data Base Reference 09)	2,277,512	722,710	
4.	1986 Pure Premium ((2c)+(3c))/(1)	9.66	6.12	
5.	Adjustment of Voluntary Experience to Total Market Exposure Distribution (1988 MARB 100A-3, page 3)	xxx	1.0000	
6.	1986 Adjusted Pure Premium (4)/(5)	9.66	6.12	3.54 *
7.	Adjustment to Residual Market Deficit Due to Effects of SDIP (1988 MARB 100A-3, page 3)	xxx	xxx	0.9098
8.	Final 1986 Adjusted Pure Premium (6) * (7)	9.66	6.44 **	3.22

* (A)-(B)
** (A)-(C)

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ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100B

DEVELOPMENT FACTORS

1988 A.G.
Summary
Schedule 100B

SUMMARY OF SCHEDULE 100B

Company .... Attorney General

Line of Business .. Private Passenger

Rates Effective ... January 1, 1988

Development Factor *

Coverage	
A-1 10/20 Limits	1.208
A-2	0.726
B, Basic 10/20 Limits	1.208
PDL, Basic	1.134
Collision $300 Deductible	0.878
Limited Collision $300 Deductible	0.566
D, Basic	1.079
E, Comprehensive $300 Deductible	1.029
U	1.876

* 1988 MARB, 100B

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100C

CLAIM COST TREND & PROJECTION FACTORS

1988 AG
Exhibit 100C-1

1988 Massachusetts Private Passenger Automobile
Summary of Claim Cost Trend Factors

Coverage	First Dollar Unlimited Coverage Trend Factor *	Trend Factor Adj. for Limits and Deductibles **
A-1 and B basic (10/20)	1.068	1.042
B excess	1.068	NA
A-2, PIP	1.137	1.067
PDL, Basic (5000)	1.084	1.074
PDL, Excess	1.084	NA
D, Medical Payments	1.192	1.170
Collision	1.066	1.080
Limited Collision	1.066	1.091
Comprehensive	NA	1.055
U Basic	1.068	1.116

* 1988 AG Exhibit 100C-2.
** 1988 AG Exhibit 100C-6, pp.1-4.

1988 Massachusetts Private Passenger Automobile
Summary of Selected Average Claim Cost Trend Factors
Prior to Effect of Deductibles and Limits

	B-I Liability A-1, B, U		PIP	Med. Pay	Property Damage Liability		Collision Ltd. Collision		$300 Ded.
	Weight	Factor	A-2	D	Weight	Factor	Weight	Factor	Comprehensive
External Trend (source: AG 100C-3)	0.6	1.089	1.137	1.192	0.6	1.053	0.6	1.054	1.055
Internal Trend Quarterly Statistical Data *	0.4	1.036			0.4	1.131	0.4	1.085	
Selected Trend Factor		1.068	1.137	1.192		1.084		1.066	1.055

* B-I and PDL from 1988 AG 100C-4, pg.1; Collision from 1988 MARB 100C-4.

1988 AG
Exhibit 100C-3
Exhibit 1

1988 Massachusetts Private Passenger Automobile
Summary of External Trend Factors

A-1, B, U	1.089 (100C-3, Exhibit 2, p.1)
A-2, PIP	1.137 (100C-3, Exhibit 2, p.1)
D, Medical Payments	1.192 (100C-3, Exhibit 2, p.1)
PDL	1.053 (100C-3, Exhibit 3, p.1)
Collision	1.054 (100C-3, Exhibit 3, p.1)
Comprehensive	1.055 (100C-3, Exhibit 4, p.1)

1988 Massachusetts Private Passenger Automobile
Calculation of External Claim Cost Trend Factors

Bodily Injury Liability	Index	Weight *	Trend Factor **
Medical Loss	CPI - Boston Medical Care	0.300	1.192
Wage Loss	Total Private Ave. Weekly Wage	0.114	1.031
General Damage	Total Private Ave. Weekly Wage	0.293	1.031
	CPI - All Items	0.293	1.064
		1.000	1.089
A-2 (PIP)			
Medical Loss	CPI - Boston Medical Care	0.660	1.192
Wage Loss	Total Private Ave. Weekly Wage	0.340	1.031
		1.000	1.137
D (Medical Payments)			
Medical Loss	CPI - Boston Medical Care	1.000	1.192

* Weights for BI determined in 1988 AG 100C-3, Exhibit 2, p.4, others from 1988 MARB, 100C-6.
** 1988 AG 100C-3, Exhibit 2, pp.2-3.

1988 Massachusetts Private Passenger Automobile
Calculation of External Trend Factors

Linear Least Squares Regression

	CPI - Boston Medical Care	Total Private Ave. Weekly Wage
(1) Latest data period *	5/87	4/87
(2) Average 1986 index value *	427.79	304.38
(3) Actual index value for (1) *	458.90	306.71
(4) Fitted index value for (1)	456.50	308.07
(5) Fitted index value for 11/1/88	507.46	315.09
(6) Linear Trend Factor = ((5)/(4)) x ((3)/(2))	1.192	1.031

NOTE: Linear Regression Model is Y = A + (B x X)

Boston Medical Care
A = 386.8606
B = 5.8035

Total Private Average Weekly Wage
A = 298.9985
B = .3781

* 1988 MARB 100C-7.

1988 Massachusetts Private Passenger Automobile
Calculation of External Trend Factors

Linear Least Squares Regression

	CPI - All Items
(1) Lastest data period *	6/87
(2) Average 1986 index value *	323.40
(3) Actual index value for (1) *	334.90
(4) Fitted index value for (1)	331.18
(5) Fitted index value for 11/1/87	340.35
(6) Linear Trend Factor = ((5)/(4)) x ((3)/(2))	1.064

NOTE: Linear Regression Model is Y = A + (B x X)
CPI - All Items
A = 317.8775
B = .5541

* 1988 AG 100C-7.

1988 Massachusetts Private Passenger Automobile

Calculation of Trended Weights for Claim Cost Components

Coverage: Bodily Injury Liability

Component	Weight *	Index (ices) Used for Component	Index Weight *	Index Values ** 10/77	Index Values ** 1986	Adjusted Component Weight Change	Adjusted Component Weight Trended	Adjusted Component Weight Balanced	Index Weights
Medical Loss	0.245	Boston Medical Care	1.00	196.70	427.79	2.175	0.533	0.300	0.300
Wage Loss	0.128	Total Priv. Avg. Wage	1.00	193.12	304.38	1.576	0.202	0.114	0.114
General Damages	0.627	Total Priv Avg. Wage	0.50	193.12	304.38	1.576		0.586	0.293
		CPI - All Items	0.50	184.50	323.40	1.753			0.293
						1.665	1.044		
							1.779	1.000	1.000
	1.000								

* Commissioner's Decision on 1985 Rates.

** 1988 AG 100C-7.

1988 Massachusetts Private Passenger Automobile
Calculation of External Claim Cost Trend Factor

PD Liability

Index	Weight *	Trend Factor #
"Total" loss of vehicle		
CPI Used Cars	0.077	0.932
CPI New Cars	0.077	1.091
BEA Used Cars	0.077	1.150
State Farm Crash Parts	0.208	0.962
Auto Repair Workers Wages	0.233	1.062
CPI Bodywork	0.221	1.105
CPI Auto Maintenance & Repair	0.107	1.089
	1.000	1.053

Collision

Index	Weight *	Trend Factor #
"Total" loss of vehicle		
CPI Used Cars	0.149	0.932
CPI New Cars	0.149	1.091
BEA Used Cars	0.149	1.150
State Farm Crash Parts	0.165	0.962
Auto Repair Workers Wages	0.154	1.062
CPI Bodywork	0.160	1.105
CPI Auto Maintenance & Repair	0.075	1.089
	1.001	1.054

* 1988 AG 100C-3, Exhibit 3, p.2-3.
\# 1988 AG 100C-3, Exhibit 5.

1988 Massachusetts Private Passenger Automobile

Calculation of Trended Weights for Claim Cost Components

Coverage: Property Damage Liability

Component	Weight *	Index (ices) Used for Component	Index Weight *	Index Values ** 1980	Index Values ** 1986	Adjusted Component Weights Change	Adjusted Component Weights Trended	Adjusted Component Weights Balanced	Index Weights
Total Losses	0.197	CPI - Used Cars	0.3333	208.10	363.20	1.745		0.230	0.077
		CPI - New Cars	0.3333	179.70	223.60	1.244			0.077
		BEA ATP New Cars	0.3333	235.29	391.80	1.665			0.077
						1.551	0.306		
Partial Losses Parts	0.341	State Farm Crash Parts	0.6667	155.00	172.60	1.114		0.312	0.208
		Bodywork	0.3333	130.90	184.80	1.412			0.104
						1.213	0.414		
Partial Losses Labor	0.357	Auto Repair Wages	0.6667	6.52	8.17	1.253		0.351	0.233
		Bodywork	0.3333	130.90	184.80	1.412			0.117
						1.306	0.466		
Partial Losses Other	0.105 #	Auto Maint. & Repair	1.0000	268.90	364.70	1.356	0.142	0.107	0.107
	1.000						1.328	1.000	1.000

* Commissioner's Decision on 1985 Rates, except as noted in footnote #.

** 1988 AG 100C-7.

\# Correcting arithmetic error on p.97 of SRB filing for 1985 Rates.

1988 Massachusetts Private Passenger Automobile

Calculation of Trended Weights for Claim Cost Components

Coverage: Collision

Component	Weight *	Index (ices) Used for Component	Index Weight *	Index Values ** 1980	Index Values ** 1986	Adjusted Component Weights Change	Adjusted Component Weights Trended	Adjusted Component Weights Balanced	Index Weights
Total Losses	0.397	CPI - Used Cars	0.3333	208.10	363.20	1.745		0.446	0.149
		CPI - New Cars	0.3333	179.70	223.60	1.244			0.149
		BEA ATP New Cars	0.3333	235.29	391.80	1.665			0.149
						1.551	0.616		
Partial Losses Parts	0.283	State Farm Crash Parts	0.6667	155.00	172.60	1.114		0.248	0.165
		Bodywork	0.3333	130.90	184.80	1.412			0.083
						1.213	0.343		
Partial Losses Labor	0.244	Auto Repair Wages	0.6667	6.52	8.17	1.253		0.231	0.154
		Bodywork	0.3333	130.90	184.80	1.412			0.077
						1.306	0.319		
Partial Losses Other	0.076 #	Auto Maint. & Repair	1.0000	268.90	364.70	1.356	0.103	0.075	0.075
	1.000						1.381	1.000	1.001

* Commissioner's Decision on 1985 Rates, except as noted in footnote #.

** 1988 AG 100C-7.

\# Correcting arithmetic error on p.97 of SRB filing for 1985 Rates.

1988 Massachusetts Private Passenger Automobile
Calculation of External Average Claim Cost Trend Factor

Comprehensive ($300 deductible basis)

Type of Loss/Code	Claim Frequency * 1986	Claim Frequency * 1988	1986 Average Claim Cost*	Average Claim Cost Trend#	1988 Average Claim Cost**
Fire (01)	0.1852	0.1852	2399	1.027	2472
Theft (02)	1.5072	1.5072	3031	1.053	3209
Glass (03)	6.9106	6.9106	257	1.056	271 ***
MM & V (05)	1.3113	1.3113	626	1.037	660
Windstorm, etc. (06)	0.0325	0.0325	1149	1.030	1192
Flood, etc. (07)	0.0031	0.0031	2599	1.030	2685
All Other (09)	0.5264	0.5264	527	1.030	551
Total	10.4763	10.4763	757 ##		799 ##

Overall Average Claim Cost Trend = 799/757 = 1.055

* See 1988 MARB 100D.
\# See 1988 AG 100C-3, Exhibit 4, pp.2-3.
** [(1985 average claim cost + $300) x trend] - $300, except Glass.
\## Weighted average by frequency.
*** (1985 average claim cost) x trend.

1988 Massachusetts Private Passenger Automobile
Calculation of External Claim Cost Trend Factors

Fire

Index	Weight *	Trend Factor #
"Total" loss of vehicle		
CPI Used Cars	0.167	0.932
CPI New Cars	0.166	1.091
BEA New Cars	0.167	1.150
CPI Auto Parts & Equipment	0.450	0.997
CPI Tires	0.050	0.989
	1.000	1.027

Theft

Index	Weight **	Trend Factor #
"Total" loss of vehicle		
CPI Used Cars	0.289	0.932
CPI New Cars	0.289	1.091
BEA New Cars	0.289	1.150
Rental Reimbursement	0.019	1.000
Auto Repair Workers Wages	0.017	1.062
CPI Bodywork	0.017	1.105
CPI Auto Maintenance & Repair	0.017	1.089
CPI Auto Parts & Equipment	0.029	0.997
CPI Tires	0.017	0.989
State Farm Crash Parts	0.017	0.962
	1.000	1.053

* Weights per Commissioner's Decision on 1985 rates, except for **.
** 1988 AG 100C-3, Exhibit 4, p.4.
\# 1988 AG 100C-3, Exhibit 5.

1988 Massachusetts Private Passenger Automobile
Calculation of External Claim Cost Trend Factors

Glass

Index	Weight *	Trend Factor **
PPI Flat Glass	0.800	1.055
Auto Repair Workers' Wages	0.200	1.062
	1.000	1.056

MM & V

Index	Weight *	Trend Factor **
State Farm Crash Parts	0.167	0.962
Auto Repair Workers' Wages	0.167	1.062
CPI Bodywork	0.332	1.105
CPI Auto Parts & Equipment	0.167	0.997
CPI Tires	0.167	0.989
	1.000	1.037

All Other Perils

Index	Weight *	Trend Factor **
CPI Auto Parts & Equipment	0.500	0.997
Auto Repair Workers' Wages	0.500	1.062
	1.000	1.030

* Weights per Commissioner's Decision on 1985 rates.
** 1988 AG 100C-3, Exhibit 5.

1988 Massachusetts Private Passenger Automobile

Calculation of Trended Weights for Claim Cost Components

Coverage: Comprehensive - Theft

Component	Weight *	Index (ices) Used for Component	Index Weight *	Index Values ** 1981	Index Values ** 1986	Adjusted Component Weights Change	Adjusted Component Weights Trended	Adjusted Component Weights Balanced	Index Weights
Total Losses	0.84	CPI - Used Cars	0.333	256.90	363.20	1.414		0.868	0.289
		CPI - New Cars	0.333	190.40	223.60	1.174			0.289
		BEA ATP New Cars	0.333	277.03	391.80	1.414			0.289
						1.334	1.121		
Rental Reimbursement	0.024	Rental Reimbursement	1.000	1.00	1.00	1.000	0.024	0.019	0.019
Other	0.136	State Farm Crash Parts	0.147	173.95	172.60	0.992		0.113	0.017
		Auto Repair Wages	0.147	6.93	8.17	1.179			0.017
		Bodywork	0.147	143.30	184.80	1.290			0.017
		Auto Maint. & Repair	0.147	294.10	364.70	1.240			0.017
		Auto Parts & Equip.	0.265	136.20	128.30	0.942			0.029
		Tires	0.147	190.70	173.60	0.910			0.017
						1.074	0.146		
							1.291	1.000	1.000

* Weights per Commissioner's Decision on 1985 Rates.
** 1988 AG 100C-7.

1988 Massachusetts Private Passenger
Calculation of External Trend Factors

Linear Least Squares Regression

	CPI Used Cars	BEA ATP New Cars	CPI New Cars	Auto Repair Shop Wages	CPI Bodywork	CPI Auto Maintenance & Repair	CPI Auto Parts & Equipment	CPI Tires	PPI Flat Glass	State Farm Crash Parts
(1) Latest data period *	3/87	6/87	6/87	6/87	6/87	6/87	6/87	6/87	6/87	1/87
(2) Average 1986 index value *	363.20	391.80	223.60	8.17	184.80	364.65	128.30	173.60	231.40	172.60
(3) Actual index value for (1) *	363.10	418.15	230.90	8.41	193.40	378.30	128.80	174.00	237.10	170.60
(4) Fitted index vlaue for (1)	354.03	413.13	232.40	8.37	192.91	378.45	127.81	172.47	236.41	170.94
(5) Fitted index value for 11/1/88	329.93	445.14	245.58	8.64	203.72	397.44	126.94	170.16	243.49	166.42
(6) Linear Trend factor = ((5)/(4)) x ((3)/(2))	0.932	1.150	1.091	1.062	1.105	1.089	0.997	0.989	1.055	0.962

* 1988 AG 100C-7.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Calculation of Internal Claim Cost Trends

Ultimate Average Claim Costs

Accident Quarter	Bodily Injury $50,000 Limits	Property Damage Liability
1985: 1	8226	1018
2	8403	1034
3	8457	1057
4	8661	1078
1986: 1	8752	1082
2	8050	1096
3	8343	1116
4	8761	1129

Intercept (t = 0 at 1984: 4)	8332.524	1005.876
Slope	27.588	15.583
Fitted Values 7/1/86	8511.847	1107.166
11/1/88	8769.245	1252.558
Calculated Trend	1.030	1.131
Internal Trend*	1.036	
Adjustments to BI trend to "no limits" basis	0.006	

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Summary of Accident Quarter Adjusted Average Claim Costs
Statistical Plan Data

Adjusted for Seasonality*

Accident Quarter	Bodily Injury $50,000 Limits	Property Damage Liability
1981: 1	7023	731
2	7540	738
3	7421	766
4	7004	776
1982: 1	7602	774
2	7436	796
3	7487	811
4	7744	830
1983: 1	7639	852
2	7999	873
3	8452	878
4	8056	899
1984: 1	8035	925
2	8226	955
3	7872	973
4	8182	1002
1985: 1	8226	1018
2	8403	1034
3	8457	1057
4	8661	1078
1986: 1	8752	1082
2	8050	1096
3	8343	1116
4	8761	1129

* See AG 100C-4, Page 3 for adjustment technique.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Adjustment for Seasonality

AG 100C-4, Page 4, Ultimate Average Claim Costs, adjusted for seasonality as follows:

(1) Let Y_i be the original series and fit the linear model

$$Y_i = ax_i + b + q_0\ I(0)_i + q_1\ I(1)_i + q_2\ I(2)_i + q_3\ I(3)_i$$

by least squares regression, subject to the constraint

$$q_0 + q_1 + q_2 + q_3 = 0,$$

where,

$x_i = 1$ for $i = 1981/1$,

$x_i = 2$ for $i = 1981/2$, etc.

and

$I(k)_i = 1$ if $x_i = k \pmod 4$

and 0 otherwise for $k = 0, 1, 2, 3$.

(2) Let

$$Y'_i = Y_i - \hat{q}_0\ I(0)_i - \hat{q}_1\ I(1)_i - \hat{q}_2\ I(2)_i - \hat{q}_3\ I(3)_i$$

be the adjusted series, where $\hat{q}_k$ is the least squares estimate of q_k for $K = 0, 1, 2, 3$.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Ultimate Average Claim Costs

Accident Quarter		BODILY INJURY Ultimate Average Cost*	Adjustment to $50,000 Limit#	Adjusted Ultimate Average Cost	PROPERTY DAMAGE LIABILITY*
1981:	1	6093	1.124	6849	717
	2	6643	1.124	7467	733
	3	6866	1.124	7717	766
	4	6188	1.124	6955	794
1982:	1	6632	1.120	7428	760
	2	6574	1.120	7363	791
	3	6949	1.120	7783	811
	4	6871	1.120	7696	848
1983:	1	6559	1.138	7464	838
	2	6965	1.138	7926	868
	3	7687	1.138	8748	878
	4	7036	1.138	8007	917
1984:	1	6981	1.126	7861	911
	2	7241	1.126	8153	950
	3	7254	1.126	8168	973
	4	7223	1.126	8133	1020
1985:	1	7260	1.109	8051	1004
	2	7511	1.109	8330	1029
	3	7893	1.109	8753	1057
	4	7766	1.109	8612	1096
1986:	1	7950	1.079	8578	1068
	2	7393	1.079	7977	1091
	3	8007	1.079	8640	1116
	4	8074	1.079	8712	1147

* 1988 AG 100C-8, Exhibit 1.
\# 1988 MARB 100C-8, Exhibit 3.

1987 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Imputing Total Limits BI Trend From Limited BI Trend

$$\text{Limit L Trend} = \left(\frac{\text{Losses limited to (L/Total Limits Trend)}}{\text{Losses Limited to L}}\right) \times \text{Tota' Limits Trend}$$

Therefore,

$$\text{Total Limits Trend} = \frac{\text{(Limit L Trend)} \times \text{(Average Claim Cost Limited to L)}}{\text{Average Claim Cost Limited to (L/Total Limits Trend)}}$$

Let T = Total Limits Trend
Let A(u) = Average Claim Cost Limited to u
Let L = 50

Then,

$$T = \frac{\text{(Limit 50 Trend)} \times \text{(Average Claim Cost Limited to 50)}}{A(50/T)}$$

To approximate A(u), consider the following data:

1986 Average Claim Costs at Ultimate
(including Market Mix Adjustment)[1]

Limit	ACC
15	5839
20	6396
25	6821
50	8233

We can get A(u) from the values above by using Lagrange Interpolation[2] of the last three points.

For $25 \leq u \leq 50$

$$A(u) = 6396 \frac{(u - 25)(u - 50)}{(20 - 25)(20 - 50)} + 6821 \frac{(u - 20)(u - 50)}{(25 - 20)(25 - 50)} + 8233 \frac{(u - 20)(u - 25)}{(50 - 20)(50 - 25)}$$

$$= (-0.95)\, u^2 + (128)\, u + 4220$$

Since Limit 50 Trend = 1.030,[+] it follows that

$$T = \frac{(1.030)(8233)}{(-0.95)(50/T)^2 + (128)(50/T) + 4220}$$

or $T^2 - 0.493T - 0.563 = 0$, implying that

$$T = \frac{(0.493) + ((-0.493)^2 + 4(0.563))^{1/2}}{2} = 1.036$$

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1 Source: 1988 MARB, 100C-8, Exhibit 3.
2 Kellison, Numerical Analysis, p. 100.
+ 1988 A.G., 100C-4, p.1

Exhibit 100C-6
Page 1

1988 Massachusetts Private Passenger Automobile
Calculation of Basic Limits Trend Factors for Bodily Injury
("Detrending Effect")

	A-1 and B Basic
1. Total limits trend factor (100C-2)	1.068
2. Applicable limit per claim	
a. Current Limit	10,000
b. "Detrending Limit" = (2a)/(1)	9,363
3. Losses at Limit#	
a. At (2a), excl. ALAE	190,063,345
b. At (2b), excl. ALAE	184,803,490
c. ALAE	15,301,653
4. Trended losses ((3b)+(3c))x(1)	213,712,293
5. Trended losses transferred from A-2 (see 100C-6, pg.2)	326,984
6. Basic limits trend factor ((4)+(5))/((3a)+(3c))	1.042

\# Data Base Reference 11 for Loss excluding ALAE; Reference 10A for ALAE.
A-1 and B: Types of Loss 01, 02, 11, 14

1988 AG
Exhibit 100C-6
Page 2

1988 Massachusetts Private Passenger Automobile
Calculation of the Effects of Basic Limits on Trend Factors

	A-2 (PIP)	D (Medical Payments)
1. Total limits trend factor (100C-2)	1.137	1.192
2. Applicable limit per claim		
a. Current Limit	2,000	5,000
b. "Detrended Limit" = (2a)/(1)	1,759	4,195
3. Losses at Limit#		
a. At (2a), excl. ALAE	65,562,416	14,943,695
b. At (2b), excl. ALAE	61,432,818	13,468,156
c. ALAE	1,490,590	206,386
4. Basic limits trend factor [(1)x((3b)+(3c))]/[(3a)+(3c)]	1.067	
5. Trended losses transferrable to other coverages [(3a)-(3b)]x(1)	4,695,353	
6. a. Medical portion of PIP Losses	0.66	
b. PIP buyers that purchase D (Reference 01)	0.46	
7. Trended losses transferrable to D (5)x(6a)x(6b)	1,425,509	1,425,509
8. Trended Basic Limit losses for D Including those transferred from PIP [((3b)+(3c))x(1)]+(7)		17,725,563
9. Pure Premium impact of inflation (8)/[(3a)+(3c)]		1.17
10. Percentage of PIP claims over $2000 that become BI liability minus percentage of PIP claims under $2000 that become BI liability	0.10	
11. Trended losses transferring to A-1 and B (10)x((5)-(7))	326,984	

Data Base reference 11 for Losses excluding ALAE; Reference 10A for ALAE
A-2: Types of Loss 23, 24, 34, 44, 45P
D: Type of Loss 05

1988 AG
Exhibit 100C-6
Page 3

1988 Massachusetts Private Passenger Passenger Automobile
Calculation of Basic Limits Trend Factors for Liability Coverages
("Detrending Effect")

	PDL Basic	U Basic
1. Total limits trend factor (100C-2)	1.084	1.068
2. Applicable limit per claim		
a. Current Limit	5,000	10,000
b. "Detrending Limit" = (2a)/(1)	4,613	9,363
3. Losses at Limit*		
a. At (2a), excl. ALAE	230,050,845	36,292,958
b. At (2b), excl. ALAE	227,879,003	34,548,826
c. ALAE	1,996,580	2,259,799
4. Trended Losses ((3b)+(3c))x(1)	249,185,132	39,311,612
5. Trended losses transferred from other coverages#		3,723,988
6. Basic limits trend factor ((4)+(5))/((3a)+(3c))	1.074	1.116

* Data Base Reference 11 for Loss excluding ALAE; Reference 10A for ALAE.
PDL: Type of Loss 03
U: Type of Loss 06
Calculated for the AG by the MARB using a trend factor of 1.068.

1988 Massachusetts Private Passenger Automobile
Calculation of $300 Deductible Trend Factors for Physical Damage Coverages

	Collision	Limited Collision
1. First dollar trend factor (100C-2)	1.066	1.066
2. 1986 $300 Deductible average claim cost (1988 MARB 100B-1)	$1,459	$799
3. 1988 $300 Deductible average claim cost, current claims [((2)+$300)x(1)]-$300	$1,575	$872
4. $300 deductible trend factor (3)/(2)	1.080	1.091

All Items
Base: 1967 = 100
Source: Bureau of Labor Statistics -- CPI

1988 AG Filing
100C-7
Page 1

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	175.3	187.1	204.7	233.3	260.7	282.1	292.1	302.7	312.6	324.3	327.7
February	177.1	188.4	207.1	236.5	263.5	282.9	292.3	303.3	313.9	323.2	329.0
March	178.2	189.7	209.3	239.9	265.2	282.5	293.0	303.3	315.3	321.4	330.5
April	179.6	191.4	211.8	242.6	266.8	283.7	294.9	304.1	316.7	320.4	332.[illegible]
May	180.6	193.3	214.3	245.1	269.1	286.5	296.3	305.4	317.8	321.4	333.4
June	181.8	195.3	216.9	247.8	271.4	290.1	297.2	306.2	318.7	323.0	334.[illegible]
July	182.6	196.7	219.4	248.0	274.6	291.8	298.2	307.5	319.1	322.9	
August	183.3	197.7	221.5	249.6	276.5	292.4	299.5	310.3	319.6	323.4	
September	184.0	199.1	223.7	251.9	279.1	293.6	300.8	312.1	320.5	324.9	
October	184.5	200.7	225.6	254.1	279.7	293.2	301.3	312.2	321.3	325.0	
November	185.4	201.8	227.6	256.4	280.4	292.0	301.4	311.9	322.6	325.4	
December	186.1	202.9	230.0	258.7	281.1	288.6	301.5	312.2	323.4	325.7	
Average	181.5	195.3	217.7	247.0	272.3	288.3	297.4	307.6	318.5	323.4	331.3

Average Transaction Price -- Used Cars
Base: 1967 = 100
Source: Bureau of Labor Statistics -- CPI

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	177.7	169.8	193.6	197.2	234.0	280.5	311.1	357.3	382.8	374.1	354.7
February	179.1	170.0	193.4	195.3	234.4	279.7	309.1	357.2	384.6	370.7	357.0
March	182.7	172.3	195.4	195.2	235.4	280.9	309.3	362.2	386.2	367.2	363.1
April	187.8	177.3	200.0	196.8	239.1	285.2	312.7	370.0	386.4	364.8	
May	191.4	184.6	205.4	199.3	245.2	291.4	317.1	378.0	384.2	363.6	
June	192.2	191.5	208.9	200.8	252.9	298.2	322.7	382.0	380.3	362.5	
July	190.6	195.8	209.2	203.4	260.3	302.4	329.6	383.2	376.7	360.3	
August	186.4	196.7	207.0	206.4	266.9	304.4	336.8	383.8	374.0	358.0	
September	182.5	195.9	202.9	214.6	272.8	304.6	343.9	384.2	374.3	359.5	
October	178.0	195.4	199.9	222.7	278.2	306.7	350.4	384.6	375.3	360.6	
November	175.0	194.7	198.4	230.8	281.4	310.5	356.1	383.6	376.4	361.0	
December	170.7	194.0	198.3	234.4	281.9	312.6	357.6	382.6	375.6	356.6	
Average	182.8	186.5	201.0	208.1	256.9	296.4	329.7	375.7	379.7	363.2	358.3

Average Transaction Price -- New Cars
Base: 1967 = 100
Source: Bureau of Economic Analysis

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	176.8	187.8	208.3	224.0	257.3	287.9	308.2	343.6	343.0	382.9	403.8
February	178.9	190.5	211.6	223.6	262.5	295.5	320.2	344.3	355.1	383.6	396.3
March	179.9	193.6	209.6	223.4	263.5	300.2	329.4	351.7	359.1	390.1	401.4
April	177.9	196.9	205.6	226.2	271.5	306.2	322.6	346.8	346.6	383.2	406.5
May	178.0	197.2	206.0	228.6	277.2	307.6	321.9	351.1	351.7	386.6	415.1
June	180.4	200.7	208.1	230.6	280.3	309.2	324.4	361.6	360.1	386.9	418.2
July	180.6	202.3	211.4	237.7	279.8	309.2	328.4	352.0	362.7	390.8	
August	182.8	203.4	216.0	238.9	280.5	310.6	335.6	354.5	373.1	391.8	
September	183.8	203.0	216.3	244.0	282.7	312.1	338.3	355.8	371.4	398.9	
October	185.7	203.4	220.3	244.0	286.1	315.3	343.8	340.3	375.7	401.2	
November	187.7	207.6	222.4	250.7	288.6	313.8	334.9	349.9	377.8	400.3	
December	188.4	209.3	219.5	251.9	294.4	316.4	327.2	360.6	377.7	404.6	
Average	181.7	199.6	212.9	235.3	277.0	307.0	327.9	351.0	362.8	391.7	406.9

Average Transaction Price -- New Cars
Base: 1967 = 3212
Source: Bureau of Economic Analysis

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	5679	6032	6691	7196	8264	9247	9899	11035	11018	12299	12971
February	5746	6120	6797	7181	8433	9493	10284	11058	11407	12322	12728
March	5777	6217	6733	7177	8463	9644	10581	11297	11533	12530	12893
April	5715	6325	6603	7264	8720	9834	10361	11139	11132	12307	13057
May	5718	6334	6618	7342	8903	9879	10340	11278	11296	12418	13334
June	5795	6448	6683	7407	9002	9933	10420	11615	11565	12428	13431
July	5801	6498	6790	7635	8986	9932	10549	11307	11650	12554	
August	5870	6534	6938	7672	9010	9976	10778	11385	11985	12586	
September	5903	6519	6948	7837	9081	10025	10867	11428	11929	12812	
October	5964	6532	7075	7836	9188	10129	11043	10929	12068	12886	
November	6029	6667	7145	8051	9271	10078	10757	11239	12135	12858	
December	6050	6723	7050	8091	9457	10163	10511	11584	12133	12996	
Average	5837.3	6412.4	6839.3	7557.4	8898.2	9861.1	10532.5	11274.5	11654.3	12583.0	13069.0

Average Transaction Price -- New Cars
Base: 1967 = 100
Source: Bureau of Labor Statistics -- CPI

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	141.1	151.0	160.8	174.1	185.7	197.3	200.8	206.7	212.4	219.2	232.0
February	140.7	151.1	162.0	175.4	185.0	195.3	201.0	206.7	213.1	219.7	229.3
March	140.9	151.1	162.4	175.4	182.7	194.2	200.9	206.7	213.4	219.5	228.5
April	140.6	151.2	163.9	177.7	186.2	195.9	200.7	206.9	213.4	220.4	229.5
May	141.4	152.2	165.3	179.6	191.2	197.3	201.3	207.1	213.8	222.3	230.3
June	141.7	153.2	165.9	179.4	192.5	197.9	201.2	207.1	214.0	223.4	230.9
July	141.6	153.6	166.6	180.0	192.9	198.5	201.0	207.6	214.0	223.9	
August	141.6	153.6	166.3	181.9	192.1	198.6	201.7	207.6	213.9	223.9	
September	141.1	153.1	165.9	182.3	191.4	197.5	202.3	207.6	213.8	223.7	
October	145.7	155.1	167.4	182.0	192.7	197.4	203.8	209.0	215.5	226.3	
November	148.2	158.1	170.9	184.5	195.2	198.7	205.7	210.8	217.8	230.0	
December	150.5	159.4	171.7	184.6	196.9	199.9	206.5	211.3	218.8	231.4	
Average	142.9	153.6	165.8	179.7	190.4	197.4	202.2	207.9	214.5	223.6	230.1

Automotive Repair Shops Average Hourly Earnings
Source: Bureau of Labor Statistics -- Labstat Series Report

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	4.86	5.21	5.71	6.35	6.77	7.22	7.37	7.55	7.84	8.18	8.30
February	4.95	5.25	5.71	6.38	6.79	7.26	7.32	7.59	7.87	8.09	8.32
March	4.92	5.31	5.63	6.39	6.77	7.24	7.40	7.64	7.86	8.14	8.34
April	5.00	5.37	5.72	6.42	6.84	7.24	7.46	7.62	7.90	8.11	8.37
May	5.01	5.35	5.85	6.46	6.82	7.22	7.47	7.70	7.97	8.15	8.39
June	5.01	5.42	5.92	6.50	6.88	7.25	7.46	7.71	8.01	8.15	8.41
July	5.02	5.42	5.91	6.53	6.96	7.27	7.49	7.70	7.99	8.10	
August	4.99	5.42	6.00	6.61	6.98	7.26	7.51	7.71	7.99	8.16	
September	5.07	5.50	6.04	6.61	7.04	7.30	7.58	7.75	8.02	8.19	
October	5.11	5.53	6.10	6.57	7.07	7.31	7.51	7.75	8.10	8.21	
November	5.14	5.60	6.14	6.67	7.10	7.29	7.54	7.80	8.09	8.24	
December	5.19	5.63	6.24	6.70	7.14	7.36	7.62	7.84	8.17	8.29	
Average	$5.02	$5.42	$5.91	$6.52	$6.93	$7.27	$7.48	$7.70	$7.98	$8.17	$8.36

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Automobile Body Work
Base: 1977 = 100
Source: Bureau of Labor Statistics -- CPI

Month	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	101.0	111.2	124.3	137.3	149.8	161.1	168.9	175.5	181.7	188.8
February	102.0	112.9	126.1	139.2	152.1	161.5	169.0	177.0	180.2	190.1
March	102.7	114.0	127.2	140.2	152.7	162.5	169.3	177.1	181.0	192.3
April	102.9	114.4	128.4	140.7	153.3	163.4	170.1	176.7	183.4	192.7
May	104.2	115.2	129.7	141.3	154.0	164.3	170.9	177.1	184.9	193.2
June	105.2	116.0	130.8	142.2	154.7	165.3	171.3	178.3	185.0	193.4
July	106.3	117.6	131.3	143.3	156.0	165.6	171.6	178.8	185.8	
August	106.8	118.6	132.4	145.4	156.8	166.0	172.1	179.3	186.3	
September	107.4	119.2	133.0	146.1	158.1	166.5	173.1	180.0	185.9	
October	108.3	120.4	134.6	147.2	159.4	167.8	174.1	180.5	186.3	
November	109.2	121.7	135.9	148.3	159.8	168.2	174.3	181.3	188.4	
December	110.0	123.1	136.7	148.9	160.2	168.3	174.7	181.5	188.7	
Average	105.5	117.0	130.9	143.3	155.6	165.0	171.6	178.6	184.8	191.8

Automobile Maintenance and Repair
Base: 1967 = 100
Source: Bureau of Labor Statistics -- CPI
(Adjusted for Seasonality)

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	196.5	212.7	232.0	256.4	283.4	306.2	325.2	336.6	347.9	359.4	373.4
February	198.0	214.9	234.2	259.0	285.2	308.4	326.6	338.1	349.2	360.4	375.1
March	199.5	215.3	236.3	261.0	287.5	311.1	327.4	339.0	349.6	360.9	377.9
April	200.7	216.3	238.3	263.6	289.2	312.8	328.1	339.6	349.3	362.2	377.9
May	202.1	218.0	240.3	265.8	291.0	314.4	329.4	340.8	350.6	362.8	378.1
June	203.0	219.9	242.1	268.0	292.6	316.8	330.2	341.5	351.5	363.6	378.3
July	204.3	221.5	244.3	270.0	293.8	318.7	330.4	342.3	352.2	365.0	
August	205.6	223.1	246.1	272.4	296.5	320.0	331.7	343.4	352.9	365.7	
September	207.0	225.2	247.7	274.2	299.4	321.3	333.0	344.9	354.5	366.6	
October	207.9	227.1	249.4	276.7	301.7	322.6	334.1	346.2	356.9	367.2	
November	209.0	228.8	251.2	278.9	303.3	323.1	335.6	346.7	357.2	369.7	
December	211.0	230.2	254.0	281.2	305.2	323.8	335.9	347.1	359.0	372.3	
Average	203.7	221.1	243.0	268.9	294.1	316.6	330.6	342.2	352.6	364.7	376.8

C88

Automobile Parts and Equipment
Base: 1977 = 100
Source: Bureau of Labor Statistics -- CPI

Month	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	100.5	109.1	121.4	132.4	140.0	139.1	130.0	128.6	129.5	128.4
February	101.2	110.5	123.9	133.4	139.4	138.5	129.6	129.9	129.2	128.3
March	101.9	110.3	124.7	133.7	139.9	137.4	128.5	128.5	129.5	128.8
April	102.6	111.3	126.2	135.4	139.2	136.4	129.4	129.2	128.7	127.3
May	102.8	111.6	126.5	136.1	140.9	135.4	128.9	128.1	129.1	128.3
June	103.8	111.9	126.3	135.5	141.2	135.0	129.0	129.8	128.2	128.8
July	104.6	113.2	128.4	135.2	140.1	134.5	127.8	128.6	128.1	
August	105.4	114.1	128.7	137.0	138.6	134.1	128.1	128.9	128.6	
September	105.8	115.7	129.8	138.4	138.1	133.8	128.0	129.6	127.5	
October	105.4	117.6	129.4	138.9	138.6	133.8	126.5	129.0	126.4	
November	107.5	119.0	130.6	139.2	139.0	134.6	128.1	128.0	127.3	
December	108.0	120.6	132.0	139.2	138.4	134.3	128.9	128.3	128.3	
Average	104.1	113.7	127.3	136.2	139.5	135.6	128.6	128.9	128.4	128.3

Tires
Base: 1967 = 100
Source: Bureau of Labor Statistics -- CPI

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	140.4	138.6	150.7	166.3	184.8	196.5	194.9	178.5	174.9	175.6	173.2
February	140.0	139.6	152.1	170.6	186.6	195.1	194.1	177.9	177.7	175.5	174.5
March	138.3	140.6	151.3	172.5	186.9	195.5	191.7	175.0	175.0	176.3	175.3
April	137.2	141.9	153.1	174.9	191.1	193.7	190.1	176.5	176.5	174.3	172.2
May	135.0	142.1	153.8	175.6	189.9	196.0	188.8	175.7	174.6	175.1	173.9
June	135.1	143.4	153.7	174.9	188.4	196.4	187.9	175.5	178.2	173.8	174.0
July	135.7	144.7	155.7	178.9	191.5	195.5	187.2	173.0	175.7	173.3	
August	137.5	146.0	156.1	179.9	194.1	193.0	186.9	174.0	175.4	174.1	
September	138.0	146.2	158.1	181.5	194.6	192.1	185.4	174.2	176.7	172.0	
October	138.3	144.7	161.1	180.8	195.1	193.2	185.4	171.5	176.0	169.8	
November	138.6	148.4	163.0	182.5	195.2	194.0	187.0	174.0	174.4	171.7	
December	138.1	149.1	165.7	184.7	190.7	193.7	186.5	175.1	174.0	171.1	
Average	137.7	143.8	156.2	176.9	190.7	194.6	188.8	175.1	175.8	173.6	173.9

090

Flat Glass
Base: 1967 = 100
Source: Bureau of Labor Statistics -- CPI

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	152.9	168.2	181.1	191.0	203.9	216.2	229.7	229.5	221.3	229.9	234.2
February	159.6	170.3	183.1	191.0	204.3	216.2	229.7	229.9	220.9	229.8	234.4
March	159.6	170.3	183.1	191.4	204.8	216.2	229.7	229.1	220.9	229.5	234.6
April	159.6	172.8	183.1	195.3	210.2	216.2	229.7	230.2	222.5	230.1	236.9
May	159.8	172.8	183.1	195.3	210.2	226.4	229.7	226.1	224.9	229.7	235.5
June	161.6	172.8	184.0	193.6	210.3	226.4	229.7	226.3	224.8	229.7	237.1
July	160.0	173.2	184.1	194.3	218.3	226.1	229.8	226.3	226.3	233.6	
August	161.1	173.6	184.1	199.5	218.3	221.1	229.7	219.6	227.4	232.4	
September	161.1	173.6	184.5	199.7	218.3	221.1	229.5	219.7	226.5	232.4	
October	162.5	173.6	184.7	200.7	218.5	221.1	229.6	219.9	228.2	232.4	
November	164.0	174.0	185.4	203.1	218.5	225.3	230.1	218.5	228.9	233.2	
December	168.2	178.9	186.4	203.0	216.1	225.3	229.9	218.6	229.5	233.6	
Average	160.8	172.8	183.9	196.5	212.6	221.5	229.7	224.5	225.2	231.4	235.5

State Farm Crash Parts
Base: 1/1976 = 100

Month	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	109.3	120.6	133.0	148.1	168.8	188.0	193.6	194.9	190.0	173.3	170.6
February											
March											
April	112.4	122.5	134.7	148.9	173.9	188.3	195.5	195.1	189.9	172.9	
May											
June											
July	113.2	124.4	136.0	156.3	173.4	189.1	197.3	195.7	188.7	172.2	
August											
September											
October	118.5	125.9	137.9	166.6	179.7	192.7	197.5	194.0	187.1	172.0	
November											
December											
Average	113.4	123.4	135.4	155.0	174.0	189.5	196.0	194.9	188.9	172.6	170.6

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Ultimate Average Claim Costs

Accident Quarter		BI-Basic Ultimate Average Cost*	BI-Total Ultimate Average Cost*	PDL Ultimate Average Cost*
1981:	1	3844	6093	717
	2	4064	6643	733
	3	4172	6866	766
	4	3997	6188	794
1982:	1	4022	6632	760
	2	4229	6574	791
	3	4386	6949	811
	4	4275	6871	848
1983:	1	4161	6559	838
	2	4446	6965	868
	3	4560	7687	878
	4	4448	7036	917
1984:	1	4457	6981	911
	2	4614	7241	950
	3	4714	7254	973
	4	4696	7223	1020
1985:	1	4741	7260	1004
	2	4804	7511	1029
	3	5043	7893	1057
	4	4959	7766	1096
1986:	1	5033	7950	1068
	2	5027	7393	1091
	3	5072	8007	1116
	4	5023	8074	1147

* 100C-8, Exhibit 2, p.1 for BI-Basic,
p.10 for BI-Total,
p.19 for PDL.

Calculation of Average Claim Costs by Accident Quarter
Adjusted Statplan Data
Bodily Injury -- Basic Limits -- A1 & B

1988 AG Filin
100C-8
Exhibit 2
Page 1

	Basic Limits Losses			Claim Counts			
Accident Quarter	Latest Losses	Loss Development Factors	Ultimate Losses	Latest Claim Count	Claim Count Development Factors	Ultimate Claim Costs	Ultimate Average Cost
1978/1	15,314,143	1.0000	15,314,143	6,339	1.0000	6,339	2,416
1978/2	19,906,354	1.0016	19,938,204	6,835	1.0000	6,835	2,917
1978/3	21,778,974	1.0017	21,815,998	7,494	0.9996	7,491	2,912
1978/4	24,124,398	1.0020	24,172,647	7,944	0.9988	7,934	3,047
1979/1	20,456,561	1.0000	20,456,561	6,828	1.0000	6,828	2,996
1979/2	23,679,773	1.0016	23,717,661	7,866	1.0000	7,866	3,015
1979/3	25,343,188	1.0017	25,386,271	8,118	0.9996	8,115	3,128
1979/4	26,966,696	1.0020	27,020,629	8,518	0.9988	8,508	3,176
1980/1	23,401,723	1.0000	23,401,723	6,766	1.0000	6,766	3,459
1980/2	30,050,466	1.0016	30,098,547	8,181	1.0000	8,181	3,679
1980/3	31,021,698	1.0017	31,074,435	7,978	0.9996	7,975	3,897
1980/4	33,277,762	1.0020	33,344,318	8,801	0.9988	8,790	3,793
1981/1	28,965,835	1.0000	28,965,835	7,536	1.0000	7,536	3,844
1981/2	32,881,757	1.0016	32,934,368	8,104	1.0000	8,104	4,064
1981/3	36,557,735	1.0017	36,619,883	8,782	0.9996	8,778	4,172
1981/4	38,564,608	1.0020	38,641,737	9,680	0.9988	9,668	3,997
1982/1	30,933,142	1.0000	30,933,142	7,691	1.0000	7,691	4,022
1982/2	35,558,504	1.0016	35,615,398	8,421	1.0000	8,421	4,229
1982/3	38,349,120	1.0017	38,414,314	8,761	0.9996	8,757	4,386
1982/4	41,528,335	1.0020	41,611,392	9,746	0.9988	9,734	4,275
1983/1	34,576,583	1.0017	34,635,363	8,337	0.9983	8,323	4,161
1983/2	42,569,621	1.0025	42,676,045	9,621	0.9977	9,599	4,446
1983/3	44,512,292	1.0050	44,734,853	9,840	0.9970	9,810	4,560
1983/4	46,576,906	1.0091	47,000,756	10,589	0.9980	10,568	4,448
1984/1	40,961,005	1.0222	41,870,339	9,341	1.0057	9,394	4,457
1984/2	47,117,063	1.0287	48,469,323	10,405	1.0095	10,504	4,614
1984/3	50,723,585	1.0352	52,509,055	10,988	1.0137	11,139	4,714
1984/4	53,885,807	1.0436	56,235,228	11,753	1.0188	11,974	4,696
1985/1	47,655,819	1.0575	50,396,029	10,347	1.0273	10,629	4,741
1985/2	52,846,834	1.0710	56,598,959	11,356	1.0374	11,781	4,804
1985/3	54,722,257	1.0937	59,849,732	11,270	1.0530	11,867	5,043
1985/4	57,931,593	1.1185	64,796,487	12,215	1.0696	13,065	4,959
1986/1	45,708,059	1.1185	51,124,464	9,496	1.0696	10,157	5,033
1986/2	55,479,013	1.1554	64,100,452	11,631	1.0963	12,751	5,027
1986/3	53,530,219	1.2218	65,403,222	11,313	1.1398	12,895	5,072
1986/4	48,386,570	1.3372	64,702,521	10,686	1.2054	12,881	5,023

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Quarterly Incurred Losses
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1978/1									
1978/2									
1978/3									
1978/4									
1979/1									
1979/2									
1979/3									
1979/4									
1980/1									
1980/2									
1980/3									
1980/4									
1981/1									
1981/2									
1981/3									
1981/4									
1982/1									
1982/2									
1982/3									37,511,290
1982/4								40,031,060	40,099,220
1983/1							32,669,641	33,106,351	33,540,406
1983/2						39,616,807	40,302,484	40,976,023	40,902,409
1983/3					40,506,084	41,935,045	42,206,184	42,627,955	43,019,481
1983/4				42,331,470	43,009,157	43,848,902	43,877,031	44,305,980	44,754,163
1984/1				37,426,580	38,505,099	39,115,899	39,741,096	40,148,375	40,447,734
1984/2			42,174,019	43,634,211	44,343,530	44,574,597	45,421,196	46,148,711	46,883,941
1984/3		42,845,586	45,312,916	46,302,621	47,173,531	48,559,107	49,468,417	50,285,580	50,723,585
1984/4	41,962,621	45,802,092	47,860,244	49,236,193	50,788,314	52,387,335	53,117,160	53,885,807	
1985/1	38,275,858	41,479,906	43,664,151	45,239,537	46,155,796	47,211,967	47,665,819		
1985/2	42,984,545	46,385,686	49,755,564	51,013,926	52,315,885	52,846,834			
1985/3	43,631,894	48,871,921	51,685,450	53,445,146	54,772,257				
1985/4	47,821,830	52,818,634	55,565,934	57,931,593					
1986/1	38,571,047	41,588,410	43,927,360	45,708,059					
1986/2	47,323,711	52,010,901	55,479,013						
1986/3	48,711,224	53,530,224							
1986/4	48,386,570								

Quarterly Incurred Losses
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Year	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
1978/1								15,449,475	15,355,108	15,314,143
1978/2								19,911,435	19,906,354	
1978/3								21,778,974		
1978/4										
1979/1								20,556,633	20,449,271	20,456,561
1979/2								23,661,244	23,679,773	
1979/3								25,343,188		
1979/4										
1980/1								23,405,561	23,226,057	23,401,723
1980/2							30,039,447	29,955,678	30,050,466	
1980/3							31,034,033	31,021,698		
1980/4							33,277,762			
1981/1						28,957,945	28,875,946	28,887,650	28,864,718	28,965,835
1981/2					32,874,776	32,851,738	32,783,062	32,778,367	32,881,757	
1981/3				36,076,991	36,240,149	36,348,825	36,461,343	36,557,735		
1981/4			38,445,504	38,461,319	38,504,130	38,504,060	38,564,608			
1982/1		30,162,964	30,651,698	30,819,988	30,821,322	30,824,746	30,814,818	30,829,828	30,951,847	30,933,142
1982/2	34,939,124	34,938,093	35,288,456	35,280,344	35,294,025	35,424,460	35,388,915	35,446,232	35,558,504	
1982/3	37,645,578	37,943,475	38,182,929	38,158,590	38,215,815	38,288,259	38,333,147	38,349,120		
1982/4	40,486,463	40,629,495	41,226,582	41,396,043	41,634,168	41,603,924	41,528,335			
1983/1	33,634,103	33,852,629	34,285,144	34,461,688	34,610,426	34,576,583				
1983/2	41,108,393	41,454,553	41,970,839	42,483,629	42,569,621					
1983/3	43,307,029	43,662,442	44,224,582	44,512,292						
1983/4	45,344,571	45,720,830	46,576,906							
1984/1	40,627,161	40,961,005								
1984/2	47,117,063									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										

Quarterly Incurred Claim Counts
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Calendar Accident Year	2	3	4	5	6	7	8	9	10
1982/1	6,477	6,869	7,118	7,330	7,420	7,536	7,568	7,619	7,673
1982/2	7,385	7,608	7,919	8,159	8,266	8,322	8,377	8,429	8,393
1982/3	7,556	7,991	8,295	8,491	8,532	8,559	8,643	8,609	8,645
1982/4	8,500	8,910	9,251	9,401	9,523	9,608	9,609	9,643	9,598
1983/1	7,015	7,358	7,640	7,892	7,994	8,058	8,097	8,167	8,234
1983/2	8,371	8,732	9,097	9,163	9,215	9,282	9,395	9,469	9,474
1983/3	8,422	8,832	9,007	9,095	9,255	9,444	9,530	9,579	9,662
1983/4	8,692	9,276	9,549	9,837	10,028	10,191	10,222	10,300	10,348
1984/1	7,757	8,328	8,493	8,803	8,953	9,037	9,103	9,190	9,232
1984/2	8,680	9,080	9,526	9,899	9,978	10,029	10,138	10,246	10,351
1984/3	8,994	9,597	10,117	10,317	10,438	10,660	10,801	10,902	10,988
1984/4	9,761	10,481	10,775	10,973	11,288	11,507	11,661	11,753	
1985/1	8985	9481	9802	10016	10,063	10,246	10,347		
1985/2	10097	10435	10902	11,038	11,245	11,356			
1985/3	9709	10357	10,759	11,074	11,270				
1985/4	10747	11,485	11,843	12,215					
1986/1	8479	8867	9248	9496					
1986/2	10486	11147	11631						
1986/3	10731	11313							
1986/4	10686								

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Quarterly Incurred Claim Counts
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Calendar Accident Year	11	12	13	14	15	16	17	18	19	20
1982/1	7,647	7,679	7,739	7,747	7,741	7,721	7,710	7,697	7,710	7,691
1982/2	8,391	8,401	8,459	8,450	8,429	8,423	8,416	8,434	8,421	
1982/3	8,695	8,739	8,767	8,777	8,768	8,765	8,774	8,761		
1982/4	9,675	9,686	9,751	9,765	9,747	9,771	9,746			
1983/1	8,224	8,247	8,318	8,340	8,360	8,337				
1983/2	9,483	9,515	9,589	9,629	9,621					
1983/3	9,678	9,714	9,824	9,840						
1983/4	10,428	10,495	10,589							
1984/1	9,279	9,341								
1984/2	10,405									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										

Quarterly Incurred Loss Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Year	2nd/3rd	3rd/4th	4th/5th	5th/6th	6th/7th	7th/8th	8th/9th	9th/10th
1978/1								
1978/2								
1978/3								
1978/4								
1979/1								
1979/2								
1979/3								
1979/4								
1980/1								
1980/2								
1980/3								
1980/4								
1981/1								
1981/2								
1981/3								
1981/4								
1982/1								
1982/2								
1982/3								
1982/4								1.0017
1983/1							1.0134	1.0131
1983/2						1.0170	1.0167	0.9982
1983/3					1.0353	1.0065	1.0100	1.0092
1983/4				1.0160	1.0195	1.0006	1.0098	1.0101
1984/1				1.0288	1.0159	1.0160	1.0102	1.0075
1984/2			1.0346	1.0163	1.0052	1.0190	1.0160	1.0159
1984/3		1.0576	1.0218	1.0188	1.0294	1.0187	1.0165	1.0087
1984/4	1.0915	1.0449	1.0287	1.0315	1.0315	1.0139	1.0145	
1985/1	1.0837	1.0527	1.0361	1.0203	1.0229	1.0096		
1985/2	1.0791	1.0726	1.0253	1.0255	1.0101			
1985/3	1.1201	1.0576	1.0340	1.0248				
1985/4	1.1045	1.0520	1.0426					
1986/1	1.0782	1.0562	1.0405					
1986/2	1.0990	1.0667						
1986/3	1.0989							
1986/4								
8 qtr. average (when possible)	1.0944	1.0575	1.0330	1.0228	1.0212	1.0127	1.0134	1.0081

Calculation of 2nd/Ult Development Factor -- Incurred

2nd/5th	5th/10th	10th/15th	15th/20th	20th/Ult
1.1955	1.0805	1.0326	1.0025	1.0000

2nd/Ult	3rd/Ult	4th/Ult	5th/Ult
1.3372	1.2218	1.1554	1.1185

Quarterly Incurred Loss Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Year	10th/11th	11th/12th	12th/13th	13th/14th	14th/15th	15th/16th	16th/17th	17th/18th	18th/19th	19th/20th
1978/1									0.9939	0.9973
1978/2									0.9997	
1978/3										
1978/4										
1979/1									0.9948	1.0004
1979/2									1.0008	
1979/3										
1979/4										
1980/1									0.9923	1.0076
1980/2								0.9972	1.0032	
1980/3								0.9996		
1980/4										
1981/1							0.9972	1.0004	0.9992	1.0035
1981/2						0.9993	0.9979	0.9999	1.0032	
1981/3					1.0045	1.0030	1.0031	1.0026		
1981/4				1.0004	1.0011	1.0000	1.0016			
1982/1			1.0162	1.0055	1.0000	1.0001	0.9997	1.0005	1.0040	0.9994
1982/2		0.9995	1.0100	0.9998	1.0004	1.0037	0.9990	1.0016	1.0032	
1982/3	1.0036	1.0079	1.0063	0.9994	1.0015	1.0019	1.0012	1.0004		
1982/4	1.0097	1.0035	1.0147	1.0041	1.0058	0.9993	0.9982			
1983/1	1.0028	1.0065	1.0128	1.0051	1.0043	0.9990				
1983/2	1.0050	1.0084	1.0125	1.0122	1.0020					
1983/3	1.0067	1.0082	1.0129	1.0065						
1983/4	1.0132	1.0083	1.0187							
1984/1	1.0044	1.0082								
1984/2	1.0050									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										
	1.0063	1.0063	1.0130	1.0041	1.0025	1.0008	0.9997	1.0003	1.0001	1.0016

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Quarterly Incurred Claim Counts Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Calendar Accident Year	2nd/3rd	3rd/4th	4th/5th	5th/6th	6th/7th	7th/8th	8th/9th	9th/10th
1982/1	1.0605	1.0362	1.0298	1.0123	1.0156	1.0042	1.0067	1.0071
1982/2	1.0302	1.0409	1.0303	1.0131	1.0068	1.0066	1.0062	0.9957
1982/3	1.0576	1.0380	1.0236	1.0048	1.0032	1.0098	0.9961	1.0042
1982/4	1.0482	1.0383	1.0162	1.0130	1.0089	1.0001	1.0035	0.9953
1983/1	1.0489	1.0383	1.0330	1.0129	1.0080	1.0048	1.0086	1.0082
1983/2	1.0431	1.0418	1.0073	1.0057	1.0073	1.0122	1.0079	1.0005
1983/3	1.0487	1.0198	1.0098	1.0176	1.0204	1.0091	1.0051	1.0087
1983/4	1.0672	1.0294	1.0302	1.0194	1.0163	1.0030	1.0076	1.0047
1984/1	1.0736	1.0198	1.0365	1.0170	1.0094	1.0073	1.0096	1.0046
1984/2	1.0461	1.0491	1.0392	1.0080	1.0051	1.0109	1.0107	1.0102
1984/3	1.0670	1.0542	1.0198	1.0117	1.0213	1.0132	1.0094	1.0079
1984/4	1.0738	1.0281	1.0184	1.0287	1.0194	1.0134	1.0079	
1985/1	1.0552	1.0339	1.0218	1.0047	1.0182	1.0099		
1985/2	1.0335	1.0448	1.0125	1.0188	1.0099			
1985/3	1.0667	1.0388	1.0293	1.0177				
1985/4	1.0687	1.0312	1.0314					
1986/1	1.0458	1.0430	1.0268					
1986/2	1.0630	1.0434						
1986/3	1.0542							
1986/4								
AVERAGE: 8 quarters (if possible)	1.0576	1.0397	1.0249	1.0158	1.0150	1.0099	1.0083	1.0050

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Quarterly Incurred Claim Counts Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Basic

Calendar Accident Year	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20
1982/1	0.9966	1.0042	1.0078	1.0010	0.9992	0.9974	0.9986	0.9983	1.0017	0.9975
1982/2	0.9998	1.0012	1.0069	0.9989	0.9975	0.9993	0.9992	1.0021	0.9985	
1982/3	1.0058	1.0051	1.0032	1.0011	0.9990	0.9997	1.0010	0.9985		
1982/4	1.0080	1.0011	1.0067	1.0014	0.9982	1.0025	0.9974			
1983/1	0.9988	1.0028	1.0086	1.0026	1.0024	0.9972				
1983/2	1.0009	1.0034	1.0078	1.0042	0.9992					
1983/3	1.0017	1.0037	1.0113	1.0016						
1983/4	1.0077	1.0064	1.0090							
1984/1	1.0051	1.0067								
1984/2	1.0052									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										
AVERAGE: 8 quarters	1.0042	1.0038	1.0077	1.0016	0.9992	0.9992	0.9991	0.9997	1.0001	0.9975

Calculation of Average Claim Costs by Accident Quarter
Adjusted Statplan Data
Bodily Injury -- Total Limits -- A1 & B

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Total Limits Losses			Claim Counts					
Latest Losses	Loss Development Factors	Ultimate Losses	Latest Claim Count	Claim Count Development Factors	Ultimate Claim Costs	Ultimate Average Cost	Adjustment To 50000 Dollar Limit	Adjusted Ultimate Average Cost
45,915,623	1.0000	45,915,623	7,536	1.0000	7,536	6,093	1.124	6,848
53,677,467	1.0029	53,833,132	8,104	1.0000	8,104	6,643	1.124	7,466
59,960,866	1.0051	60,267,049	8,782	0.9996	8,778	6,865	1.124	7,717
59,333,301	1.0083	59,827,115	9,680	0.9988	9,668	6,188	1.124	6,955
51,006,028	1.0000	51,006,028	7,691	1.0000	7,691	6,632	1.120	7,428
55,203,015	1.0029	55,363,104	8,421	1.0000	8,421	6,574	1.120	7,363
60,543,431	1.0051	60,852,589	8,761	0.9996	8,757	6,949	1.120	7,782
66,329,375	1.0083	66,881,416	9,746	0.9988	9,734	6,871	1.120	7,695
54,097,507	1.0091	54,591,384	8,337	0.9983	8,323	6,559	1.138	7,464
65,924,945	1.0141	66,854,487	9,621	0.9977	9,599	6,965	1.138	7,926
74,220,407	1.0161	75,415,356	9,840	0.9970	9,810	7,687	1.138	8,748
72,716,678	1.0225	74,352,803	10,589	0.9980	10,568	7,036	1.138	8,007
63,154,347	1.0385	65,585,789	9,341	1.0057	9,394	6,981	1.126	7,861
72,410,422	1.0504	76,059,907	10,405	1.0095	10,504	7,241	1.126	8,154
76,213,259	1.0602	80,801,297	10,988	1.0137	11,139	7,254	1.126	8,168
80,204,407	1.0783	86,484,412	11,753	1.0188	11,974	7,223	1.126	8,133
70,016,396	1.1022	77,172,072	10,347	1.0273	10,629	7,260	1.109	8,052
78,638,323	1.1252	88,483,841	11,356	1.0374	11,781	7,511	1.109	8,330
80,095,461	1.1694	93,663,632	11,270	1.0530	11,867	7,893	1.109	8,753
83,282,751	1.2183	101,463,376	12,215	1.0696	13,065	7,766	1.109	8,612
66,274,961	1.2183	80,742,785	9,496	1.0696	10,157	7,950	1.079	8,578
73,337,092	1.2855	94,274,832	11,631	1.0963	12,751	7,393	1.079	7,978
74,037,138	1.3946	103,252,193	11,313	1.1398	12,895	8,007	1.079	8,640
66,302,891	1.5686	104,002,715	10,686	1.2054	12,881	8,074	1.079	8,712

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Quarterly Incurred Losses
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1978\1									
1978\2									
1978\3									
1978\4									
1979\1									
1979\2									
1979\3									
1979\4									
1980\1									
1980\2									
1980\3									
1980\4									
1981\1									
1981\2									
1981\3									
1981\4									
1982\1									
1982\2									
1982\3									58,015,345
1982\4								61,377,535	62,244,145
1983\1							49,133,650	51,232,085	52,177,104
1983\2						59,042,890	60,794,062	62,591,789	62,784,871
1983\3					64,092,364	67,688,458	68,580,834	69,196,845	70,850,339
1983\4				61,607,432	63,517,528	65,861,086	66,664,592	67,888,139	69,438,900
1984\1				52,537,504	55,983,739	58,255,104	60,325,566	61,313,344	62,330,170
1984\2			59,381,446	63,439,330	65,691,994	67,169,773	68,774,746	70,121,001	71,808,047
1984\3		58,083,690	63,203,147	65,794,912	68,656,197	72,350,521	73,657,963	75,166,916	76,213,259
1984\4	56,229,753	62,653,681	66,724,334	70,733,211	73,742,160	77,081,445	78,512,097	80,204,407	
1985\1	50,513,812	56,252,537	61,295,261	64,027,094	66,756,439	68,943,375	70,016,396		
1985\2	57,519,662	63,455,252	70,447,806	74,074,870	76,619,696	78,638,323			
1985\3	58,698,858	67,417,242	73,401,126	77,055,736	80,095,461				
1985\4	64,201,673	72,567,523	77,865,964	83,282,751					
1986\1	52,506,328	58,234,446	62,716,851	66,274,961					
1986\2	59,626,791	67,448,792	73,337,092						
1986\3	64,505,480	74,037,143							
1986\4	66,302,891								

Quarterly Incurred Losses
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Year	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
1978\1								22,204,682	21,966,325	21,965,110
1978\2								29,117,940	29,130,443	
1978\3								32,297,286		
1978\4										
1979\1								30,729,535	30,671,992	30,647,245
1979\2								36,357,488	36,533,403	
1979\3								38,312,929		
1979\4										
1980\1								37,052,785	36,678,448	36,945,506
1980\2							47,088,264	47,052,477	47,312,705	
1980\3							49,158,798	49,472,691		
1980\4							51,773,561			
1981\1						45,176,517	45,393,862	45,750,824	45,770,592	45,915,623
1981\2					52,873,948	53,340,553	53,199,416	53,231,161	53,677,467	
1981\3				59,132,112	59,273,297	59,413,812	59,591,229	59,960,866		
1981\4			58,515,553	58,590,595	58,960,143	59,185,125	59,333,301			
1982\1		48,608,633	49,751,005	49,986,206	49,953,375	50,167,366	50,410,997	50,523,300	50,757,679	51,006,028
1982\2	53,282,886	53,661,481	54,446,828	54,510,341	54,718,239	55,265,208	54,868,478	54,889,341	55,203,015	
1982\3	58,729,275	59,614,834	59,953,240	60,230,110	59,788,871	60,147,587	60,367,329	60,543,431		
1982\4	62,933,585	63,576,285	65,162,703	65,599,340	66,209,684	66,503,850	66,329,375			
1983\1	52,405,734	52,855,137	53,553,204	53,926,877	54,118,097	54,097,507				
1983\2	63,454,079	64,277,970	64,866,421	65,994,028	65,924,945					
1983\3	71,447,152	72,430,158	73,685,703	74,220,407						
1983\4	70,523,192	71,558,930	72,716,678							
1984\1	62,548,207	63,154,347								
1984\2	72,410,422									
1984\3										
1984\4										
1985\1										
1985\2										
1985\3										
1985\4										
1986\1										
1986\2										
1986\3										
1986\4										

Quarterly Incurred Claim Counts
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Calendar Accident Year	2	3	4	5	6	7	8	9	10
1982/1	6,477	6,869	7,118	7,330	7,420	7,536	7,568	7,619	7,673
1982/2	7,385	7,608	7,919	8,159	8,266	8,322	8,377	8,429	8,393
1982/3	7,556	7,991	8,295	8,491	8,532	8,559	8,643	8,609	8,645
1982/4	8,500	8,910	9,251	9,401	9,523	9,608	9,609	9,643	9,598
1983/1	7,015	7,358	7,640	7,892	7,994	8,058	8,097	8,167	8,234
1983/2	8,371	8,732	9,097	9,163	9,215	9,282	9,395	9,469	9,474
1983/3	8,422	8,832	9,007	9,095	9,255	9,444	9,530	9,579	9,662
1983/4	8,692	9,276	9,549	9,837	10,028	10,191	10,222	10,300	10,348
1984/1	7,757	8,328	8,493	8,803	8,953	9,037	9,103	9,190	9,232
1984/2	8,680	9,080	9,526	9,899	9,978	10,029	10,138	10,246	10,351
1984/3	8,994	9,597	10,117	10,317	10,438	10,660	10,801	10,902	10,988
1984/4	9,761	10,481	10,775	10,973	11,288	11,507	11,661	11,753	
1985/1	8985	9481	9802	10016	10,063	10,246	10,347		
1985/2	10097	10435	10902	11,038	11,245	11,356			
1985/3	9709	10357	10,759	11,074	11,270				
1985/4	10747	11,485	11,843	12,215					
1986/1	8479	8867	9248	9496					
1986/2	10486	11147	11631						
1986/3	10731	11313							
1986/4	10686								

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Quarterly Incurred Claim Counts
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Calendar Accident Year	11	12	13	14	15	16	17	18	19	20
1982/1	7,647	7,679	7,739	7,747	7,741	7,721	7,710	7,697	7,710	7,691
1982/2	8,391	8,401	8,459	8,450	8,429	8,423	8,416	8,434	8,421	
1982/3	8,695	8,739	8,767	8,777	8,768	8,765	8,774	8,761		
1982/4	9,675	9,686	9,751	9,765	9,747	9,771	9,746			
1983/1	8,224	8,247	8,318	8,340	8,360	8,337				
1983/2	9,483	9,515	9,589	9,629	9,621					
1983/3	9,678	9,714	9,824	9,840						
1983/4	10,428	10,495	10,589							
1984/1	9,279	9,341								
1984/2	10,405									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										

Quarterly Incurred Loss Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Year	2nd/3rd	3rd/4th	4th/5th	5th/6th	6th/7th	7th/8th	8th/9th	9th/10th
1978/1								
1978/2								
1978/3								
1978/4								
1979/1								
1979/2								
1979/3								
1979/4								
1980/1								
1980/2								
1980/3								
1980/4								
1981/1								
1981/2								
1981/3								
1981/4								
1982/1								
1982/2								
1982/3								
1982/4								1.0141
1983/1							1.0427	1.0184
1983/2						1.0295	1.0296	1.0031
1983/3					1.0561	1.0132	1.0090	1.0239
1983/4				1.0310	1.0369	1.0122	1.0184	1.0228
1984/1				1.0656	1.0406	1.0355	1.0164	1.0166
1984/2			1.0683	1.0355	1.0225	1.0239	1.0196	1.0241
1984/3		1.0881	1.0410	1.0435	1.0538	1.0181	1.0205	1.0139
1984/4	1.1142	1.0650	1.0601	1.0425	1.0453	1.0186	1.0216	
1985/1	1.1136	1.0896	1.0446	1.0426	1.0328	1.0156		
1985/2	1.1032	1.1102	1.0515	1.0344	1.0263			
1985/3	1.1485	1.0888	1.0498	1.0394				
1985/4	1.1303	1.0730	1.0696					
1986/1	1.1091	1.0770	1.0567					
1986/2	1.1312	1.0873						
1986/3	1.1478							
1986/4								
8 qtr. average (when possible)	1.1247	1.0849	1.0552	1.0418	1.0393	1.0208	1.0222	1.0171

Calculation of 2nd/Ult Development Factor -- Incurred

2nd/5th	5th/10th	10th/15th	15th/20th	20th/Ult
1.2876	1.1492	1.0454	1.0141	1.0000

2nd/Ult	3rd/Ult	4th/Ult	5th/Ult
1.5686	1.3946	1.2855	1.2183

Quarterly Incurred Loss Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Year	10th/11th	11th/12th	12th/13th	13th/14th	14th/15th	15th/16th	16th/17th	17th/18th	18th/19th	19th/20th
1978/1									0.9893	0.9999
1978/2									1.0004	
1978/3										
1978/4										
1979/1									0.9981	0.9992
1979/2									1.0048	
1979/3										
1979/4										
1980/1									0.9899	1.0073
1980/2								0.9992	1.0055	
1980/3								1.0064		
1980/4										
1981/1							1.0048	1.0079	1.0004	1.0032
1981/2						1.0088	0.9974	1.0006	1.0084	
1981/3					1.0024	1.0024	1.0030	1.0062		
1981/4				1.0013	1.0063	1.0038	1.0025			
1982/1			1.0235	1.0047	0.9993	1.0043	1.0049	1.0022	1.0046	1.0049
1982/2		1.0068	1.0146	1.0012	1.0038	1.0100	0.9928	1.0004	1.0057	
1982/3	1.0123	1.0151	1.0057	1.0046	0.9927	1.0060	1.0037	1.0029		
1982/4	1.0111	1.0102	1.0250	1.0067	1.0093	1.0044	0.9974			
1983/1	1.0044	1.0086	1.0132	1.0070	1.0035	0.9996				
1983/2	1.0107	1.0130	1.0092	1.0174	0.9990					
1983/3	1.0084	1.0138	1.0173	1.0073						
1983/4	1.0156	1.0147	1.0162							
1984/1	1.0035	1.0097								
1984/2	1.0084									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										
8 qtr. average (when possible)	1.0093	1.0115	1.0156	1.0063	1.0020	1.0049	1.0008	1.0032	1.0022	1.0029

Quarterly Incurred Claim Counts Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Calendar Accident Year	2nd/3rd	3rd/4th	4th/5th	5th/6th	6th/7th	7th/8th	8th/9th	9th/10th
1982/1	1.0605	1.0362	1.0298	1.0123	1.0156	1.0042	1.0067	1.0071
1982/2	1.0302	1.0409	1.0303	1.0131	1.0068	1.0066	1.0062	0.9957
1982/3	1.0576	1.0380	1.0236	1.0048	1.0032	1.0098	0.9961	1.0042
1982/4	1.0482	1.0383	1.0162	1.0130	1.0089	1.0001	1.0035	0.9953
1983/1	1.0489	1.0383	1.0330	1.0129	1.0080	1.0048	1.0086	1.0082
1983/2	1.0431	1.0418	1.0073	1.0057	1.0073	1.0122	1.0079	1.0005
1983/3	1.0487	1.0198	1.0098	1.0176	1.0204	1.0091	1.0051	1.0087
1983/4	1.0672	1.0294	1.0302	1.0194	1.0163	1.0030	1.0076	1.0047
1984/1	1.0736	1.0198	1.0365	1.0170	1.0094	1.0073	1.0096	1.0046
1984/2	1.0461	1.0491	1.0392	1.0080	1.0051	1.0109	1.0107	1.0102
1984/3	1.0670	1.0542	1.0198	1.0117	1.0213	1.0132	1.0094	1.0079
1984/4	1.0738	1.0281	1.0184	1.0287	1.0194	1.0134	1.0079	
1985/1	1.0552	1.0339	1.0218	1.0047	1.0182	1.0099		
1985/2	1.0335	1.0448	1.0125	1.0188	1.0099			
1985/3	1.0667	1.0388	1.0293	1.0177				
1985/4	1.0687	1.0312	1.0314					
1986/1	1.0458	1.0430	1.0268					
1986/2	1.0630	1.0434						
1986/3	1.0542							
1986/4								
AVERAGE: 8 quarters (if possible)	1.0576	1.0397	1.0249	1.0158	1.0150	1.0099	1.0083	1.0050

Quarterly Incurred Claim Counts Development
Statistical Plan Data -- Adjusted
Bodily Injury Liability -- Total

Calendar Accident Year	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20
1982/1	0.9966	1.0042	1.0078	1.0010	0.9992	0.9974	0.9986	0.9983	1.0017	0.9975
1982/2	0.9998	1.0012	1.0069	0.9989	0.9975	0.9993	0.9992	1.0021	0.9985	
1982/3	1.0058	1.0051	1.0032	1.0011	0.9990	0.9997	1.0010	0.9985		
1982/4	1.0080	1.0011	1.0067	1.0014	0.9982	1.0025	0.9974			
1983/1	0.9988	1.0028	1.0086	1.0026	1.0024	0.9972				
1983/2	1.0009	1.0034	1.0078	1.0042	0.9992					
1983/3	1.0017	1.0037	1.0113	1.0016						
1983/4	1.0077	1.0064	1.0090							
1984/1	1.0051	1.0067								
1984/2	1.0052									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										
AVERAGE: 8 quarters (if possible)	1.0042	1.0038	1.0077	1.0016	0.9992	0.9992	0.9991	0.9997	1.0001	0.9975

Calculation of Average Claim Costs by Accident Quarter
Adjusted Statplan Data
Property Damage Liability ($5000 Limit)

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	Losses ($5000 Limit)			Claim Counts			
Accident Quarter	Latest Losses	Loss Development Factors	Ultimate Losses	Latest Claim Count	Claim Count Development Factors	Ultimate Claim Costs	Ultimate Average Cost
1978/1	31,852,077	1.0000	31,852,077	6,339	1.0000	6,339	5,025
1978/2	26,152,432	1.0004	26,162,893	6,835	1.0001	6,836	3,827
1978/3	28,663,609	1.0008	28,686,540	7,494	1.0002	7,495	3,827
1978/4	35,864,715	1.0013	35,911,339	7,944	1.0004	7,947	4,519
1979/1	32,424,482	1.0000	32,424,482	55,724	1.0000	55,724	582
1979/2	31,920,144	1.0004	31,932,912	53,188	1.0001	53,193	600
1979/3	31,436,150	1.0008	31,461,299	50,964	1.0002	50,974	617
1979/4	37,792,949	1.0013	37,842,080	58,255	1.0004	58,278	649
1980/1	33,081,591	1.0000	33,081,591	50,504	1.0000	50,504	655
1980/2	35,218,006	1.0004	35,232,093	52,965	1.0001	52,970	665
1980/3	33,739,914	1.0008	33,766,906	49,919	1.0002	49,929	676
1980/4	44,310,220	1.0013	44,367,823	62,015	1.0004	62,040	715
1981/1	39,031,049	1.0000	39,031,049	54,402	1.0000	54,402	717
1981/2	36,580,948	1.0004	36,595,580	49,896	1.0001	49,901	733
1981/3	38,169,282	1.0008	38,199,817	49,860	1.0002	49,870	766
1981/4	50,719,925	1.0013	50,785,861	63,972	1.0004	63,998	794
1982/1	44,982,545	1.0000	44,982,545	59,168	1.0000	59,168	760
1982/2	40,269,805	1.0004	40,285,913	50,904	1.0001	50,909	791
1982/3	37,284,921	1.0008	37,314,755	46,009	1.0002	46,018	811
1982/4	47,377,693	1.0013	47,439,311	55,921	1.0004	55,943	848
1983/1	44,343,748	1.0020	44,432,501	53,015	1.0007	53,052	838
1983/2	43,294,672	1.0029	43,420,227	49,980	1.0012	50,040	868
1983/3	41,037,287	1.0041	41,205.540	46,818	1.0019	46,907	878
1983/4	53,453,903	1.0067	53,812,044	58,471	1.0036	58,681	917
1984/1	52,869,545	1.0107	53,435,249	58,244	1.0067	58,635	911
1984/2	48,150,350	1.0159	48,915,941	50,972	1.0102	51,494	950
1984/3	47,839,997	1.0219	48,887,693	49,526	1.0145	50,243	973
1984/4	58,884,967	1.0293	60,610,297	58,263	1.0203	59,443	1,020
1985/1	57,287,895	1.0406	59,615,061	57,713	1.0285	59,359	1,004
1985/2	53,351,483	1.0560	56,340,420	52,643	1.0400	54,751	1,029
1985/3	52,007,374	1.0787	56,101,811	50,200	1.0577	53,098	1,057
1985/4	63,298,666	1.1170	70,704,610	59,276	1.0879	64,485	1,096
1986/1	54,514,316	1.1170	60,892,491	52,405	1.0879	57,010	1,068
1986/2	53,273,372	1.1866	63,214,183	50,736	1.1424	57,959	1,091
1986/3	47,542,262	1.3296	63,212,192	45,149	1.2543	56,631	1,116
1986/4	39,339,572	1.7313	68,108,601	38,275	1.5516	59,387	1,147

Quarterly Paid Losses
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
1978/1									
1978/2									
1978/3									
1978/4									
1979/1									
1979/2									
1979/3									
1979/4									
1980/1									
1980/2									
1980/3									
1980/4									
1981/1									
1981/2									
1981/3									
1981/4									
1982/1									
1982/2									
1982/3									36,717,368
1982/4								46,310,657	46,560,648
1983/1							43,038,699	43,369,552	43,648,367
1983/2						41,282,106	41,718,330	42,177,900	42,446,878
1983/3					38,364,773	38,942,464	39,500,975	39,826,749	40,124,069
1983/4				48,251,067	49,671,707	50,637,604	51,338,502	51,820,936	52,246,557
1984/1				48,110,462	49,603,502	50,541,610	51,277,552	51,792,826	52,199,465
1984/2			41,226,589	43,640,854	45,084,763	46,012,928	46,724,566	47,327,742	47,757,820
1984/3		37,174,514	41,374,501	43,591,216	45,079,105	46,115,913	46,821,421	47,350,114	47,839,997
1984/4	35,120,765	45,866,485	50,900,192	53,905,151	55,837,816	57,241,805	58,135,133	58,884,967	
1985/1	35,657,416	44,969,818	49,956,878	52,946,278	54,957,820	56,237,119	57,287,895		
1985/2	31,961,816	41,375,057	46,655,148	49,888,009	51,973,264	53,351,483			
1985/3	30,672,811	41,024,773	46,824,035	49,950,665	52,007,374				
1985/4	39,065,962	52,580,742	59,230,567	63,298,666					
1986/1	35,954,303	45,921,562	51,300,583	54,514,316					
1986/2	36,618,763	47,662,085	53,273,372						
1986/3	36,767,423	47,542,262							
1986/4	39,339,572								

Quarterly Paid Losses
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Year	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th
1978/1									31,835,991	31,852,077
1978/2									26,152,432	
1978/3										
1978/4										
1979/1								32,397,316	32,412,399	32,424,482
1979/2								31,902,253	31,920,144	
1979/3								31,436,150		
1979/4										
1980/1								33,056,711	33,070,075	33,081,591
1980/2							35,200,794	35,212,355	35,218,006	
1980/3							33,723,509	33,739,914		
1980/4							44,310,220			
1981/1						38,945,933	38,974,677	38,983,387	39,008,539	39,031,049
1981/2					36,505,990	36,549,413	36,570,654	36,578,269	36,580,948	
1981/3				38,054,583	38,093,272	38,128,823	38,139,736	38,169,282		
1981/4			50,453,933	50,561,651	50,611,713	50,676,054	50,719,925			
1982/1		44,599,803	44,709,250	44,807,579	44,856,795	44,893,345	44,917,287	44,952,490	44,972,995	44,982,545
1982/2	39,765,651	39,879,559	40,013,978	40,114,087	40,160,647	40,191,938	40,230,819	40,245,118	40,269,805	
1982/3	36,864,331	37,011,607	37,096,536	37,172,464	37,212,747	37,237,446	37,261,075	37,284,921		
1982/4	46,814,119	46,989,999	47,118,850	47,233,086	47,285,244	47,326,073	47,377,693			
1983/1	43,820,996	43,996,588	44,149,324	44,287,722	44,328,842	44,343,748				
1983/2	42,684,521	42,862,190	43,066,376	43,211,716	43,294,672					
1983/3	40,356,958	40,626,004	40,900,804	41,037,287						
1983/4	52,657,559	53,130,831	53,453,903							
1984/1	52,533,497	52,869,545								
1984/2	48,150,350									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										

Quarterly Paid Claim Counts
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Calendar Accident Year	2	3	4	5	6	7	8	9	10
1982/1	42,173	49,969	53,781	55,750	57,010	57,714	58,188	58,451	58,634
1982/2	35,655	42,926	46,056	47,961	48,999	49,640	49,977	50,225	50,397
1982/3	32,725	38,722	41,775	43,316	44,317	44,829	45,186	45,381	45,535
1982/4	37,602	46,467	50,335	52,565	53,703	54,374	54,781	55,092	55,320
1983/1	36,986	44,362	48,002	49,855	50,868	51,452	51,895	52,169	52,430
1983/2	34,663	41,902	45,019	46,006	47,706	48,343	48,687	49,084	49,299
1983/3	32,761	39,094	42,104	43,680	44,633	45,146	45,597	45,841	46,075
1983/4	37,308	46,919	51,426	54,051	55,337	56,176	56,754	57,176	57,510
1984/1	37,697	46,740	51,349	53,970	55,348	56,191	56,776	57,266	57,637
1984/2	32,770	41,388	45,189	47,277	48,464	49,226	49,803	50,327	50,662
1984/3	33,105	40,549	44,200	46,070	47,265	48,134	48,708	49,149	49,526
1984/4	37,847	47,349	51,637	54,116	55,825	56,942	57,653	58,263	
1985/1	39,371	47,532	51,637	54,264	55,813	56,828	57,713		
1985/2	35,344	43,171	47,529	49,874	51,532	52,643			
1985/3	32,968	41,441	46,070	48,554	50,200				
1985/4	39,994	50,715	56,041	59,276					
1986/1	36,979	45,245	49,781	52,405					
1986/2	37,306	46,168	50,736						
1986/3	36,705	45,149							
1986/4	38,275								

Quarterly Paid Claim Counts
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Calendar Accident Year	11	12	13	14	15	16	17	18	19	20
1982/1	58,760	58,892	58,998	59,062	59,096	59,121	59,138	59,154	59,161	59,168
1982/2	50,521	50,630	50,739	50,806	50,849	50,879	50,889	50,894	50,904	
1982/3	45,651	45,780	45,872	45,931	45,965	45,979	45,997	46,009		
1982/4	55,510	55,653	55,748	55,846	55,880	55,906	55,921			
1983/1	52,601	52,744	52,871	52,966	53,000	53,015				
1983/2	49,480	49,629	49,814	49,928	49,980					
1983/3	46,275	46,403	46,714	46,818						
1983/4	57,809	58,202	58,471							
1984/1	57,924	58,244								
1984/2	50,972									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										

Quarterly Paid Loss Development
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Year	2nd/3rd	3rd/4th	4th/5th	5th/6th	6th/7th	7th/8th	8th/9th	9th/10th
1978/1								
1978/2								
1978/3								
1978/4								
1979/1								
1979/2								
1979/3								
1979/4								
1980/1								
1980/2								
1980/3								
1980/4								
1981/1								
1981/2								
1981/3								
1981/4								
1982/1								
1982/2								
1982/3								
1982/4								1.0054
1983/1							1.0077	1.0064
1983/2						1.0106	1.0110	1.0064
1983/3					1.0151	1.0143	1.0082	1.0075
1983/4				1.0294	1.0194	1.0138	1.0094	1.0082
1984/1				1.0310	1.0189	1.0146	1.0100	1.0079
1984/2			1.0586	1.0331	1.0206	1.0155	1.0129	1.0091
1984/3		1.1130	1.0536	1.0341	1.0230	1.0153	1.0113	1.0103
1984/4	1.3060	1.1097	1.0590	1.0359	1.0251	1.0156	1.0129	
1985/1	1.2612	1.1109	1.0598	1.0380	1.0233	1.0187		
1985/2	1.2945	1.1276	1.0693	1.0418	1.0265			
1985/3	1.3375	1.1414	1.0668	1.0412				
1985/4	1.3459	1.1265	1.0687					
1986/1	1.2772	1.1171	1.0626					
1986/2	1.3016	1.1177						
1986/3	1.2931							
1986/4								
8 qtr. average	1.3021	1.1205	1.0623	1.0356	1.0215	1.0148	1.0104	1.0076

Quarterly Paid Loss Development
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Year	10th/11th	11th/12th	12th/13th	13th/14th	14th/15th	15th/16th	16th/17th	17th/18th	18th/19th	19th/20th
1978/1										1.0005
1978/2										
1978/3										
1978/4										
1979/1									1.0005	1.0004
1979/2									1.0006	
1979/3										
1979/4										
1980/1									1.0004	1.0003
1980/2								1.0003	1.0002	
1980/3								1.0005		
1980/4										
1981/1							1.0007	1.0002	1.0006	1.0006
1981/2						1.0012	1.0006	1.0002	1.0001	
1981/3					1.0010	1.0009	1.0003	1.0008		
1981/4				1.0021	1.0010	1.0013	1.0009			
1982/1			1.0025	1.0022	1.0011	1.0008	1.0005	1.0008	1.0005	1.0002
1982/2		1.0029	1.0034	1.0025	1.0012	1.0008	1.0010	1.0004	1.0006	
1982/3	1.0040	1.0040	1.0023	1.0020	1.0011	1.0007	1.0006	1.0006		
1982/4	1.0054	1.0038	1.0027	1.0024	1.0011	1.0009	1.0011			
1983/1	1.0041	1.0040	1.0035	1.0031	1.0009	1.0003				
1983/2	1.0051	1.0042	1.0048	1.0034	1.0019					
1983/3	1.0058	1.0067	1.0068	1.0033						
1983/4	1.0079	1.0090	1.0061							
1984/1	1.0064	1.0064								
1984/2	1.0082									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										
8 qtr. averag (when possible)	1.0059	1.0051	1.0040	1.0026	1.0012	1.0009	1.0007	1.0005	1.0004	1.0004

Quarterly Paid Claim Count Development
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Calendar Accident Year								
1982/1	1.1849	1.0763	1.0366	1.0226	1.0123	1.0082	1.0045	1.0031
1982/2	1.2039	1.0729	1.0414	1.0216	1.0131	1.0068	1.0050	1.0034
1982/3	1.1833	1.0788	1.0369	1.0231	1.0116	1.0080	1.0043	1.0034
1982/4	1.2358	1.0832	1.0443	1.0216	1.0125	1.0075	1.0057	1.0041
1983/1	1.1994	1.0821	1.0386	1.0203	1.0115	1.0086	1.0053	1.0050
1983/2	1.2088	1.0744	1.0219	1.0370	1.0134	1.0071	1.0082	1.0044
1983/3	1.1933	1.0770	1.0374	1.0218	1.0115	1.0100	1.0054	1.0051
1983/4	1.2576	1.0961	1.0510	1.0238	1.0152	1.0103	1.0074	1.0058
1984/1	1.2399	1.0986	1.0510	1.0255	1.0152	1.0104	1.0086	1.0065
1984/2	1.2630	1.0918	1.0462	1.0251	1.0157	1.0117	1.0105	1.0067
1984/3	1.2249	1.0900	1.0423	1.0259	1.0184	1.0119	1.0091	1.0077
1984/4	1.2511	1.0906	1.0480	1.0316	1.0200	1.0125	1.0106	
1985/1	1.2073	1.0864	1.0509	1.0285	1.0182	1.0156		
1985/2	1.2215	1.1009	1.0493	1.0332	1.0216			
1985/3	1.2570	1.1117	1.0539	1.0339				
1985/4	1.2681	1.1050	1.0577					
1986/1	1.2235	1.1003	1.0527					
1986/2	1.2375	1.0989						
1986/3	1.2301							
1986/4								
AVERAGE: 8 quarters	1.2370	1.0980	1.0501	1.0285	1.0170	1.0112	1.0081	1.0057

Quarterly Paid Claim Count Development
Statistical Plan Data -- Adjusted
Property Damage Liability -- Basic

Calendar Accident Year										
1982/1	1.0021	1.0022	1.0018	1.0011	1.0006	1.0004	1.0003	1.0003	1.0001	1.0001
1982/2	1.0025	1.0022	1.0022	1.0013	1.0008	1.0006	1.0002	1.0001	1.0002	
1982/3	1.0025	1.0028	1.0020	1.0013	1.0007	1.0003	1.0004	1.0003		
1982/4	1.0034	1.0026	1.0017	1.0018	1.0006	1.0005	1.0003			
1983/1	1.0033	1.0027	1.0024	1.0018	1.0006	1.0003				
1983/2	1.0037	1.0030	1.0037	1.0023	1.0010					
1983/3	1.0043	1.0028	1.0067	1.0022						
1983/4	1.0052	1.0068	1.0046							
1984/1	1.0050	1.0055								
1984/2	1.0061									
1984/3										
1984/4										
1985/1										
1985/2										
1985/3										
1985/4										
1986/1										
1986/2										
1986/3										
1986/4										
AVERAGE: 8 quarters	1.0042	1.0035	1.0031	1.0017	1.0007	1.0004	1.0003	1.0002	1.0002	1.0001

1988 A.G.
Exhibit 100C-9
Page 1

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Projected Average Accident Date

Extrapolation of First Differences

	First Differences	Fitted First Differences
78-79	0.50	
79-80	0.40	
80-81	0.35	
81-82	0.39	0.38
82-83	0.32	0.33
83-84	0.25	0.28
84-85	0.26	0.22
85-86	0.16	0.17

1988 estimated by linear extrapolation of first differences
Using latest 5 points ($r^2 = .9222$)

	First Differences	Average Effective Date	
86-87	0.120	4.010	May 1, 1987
87-88	0.068	4.078	May 2, 1988

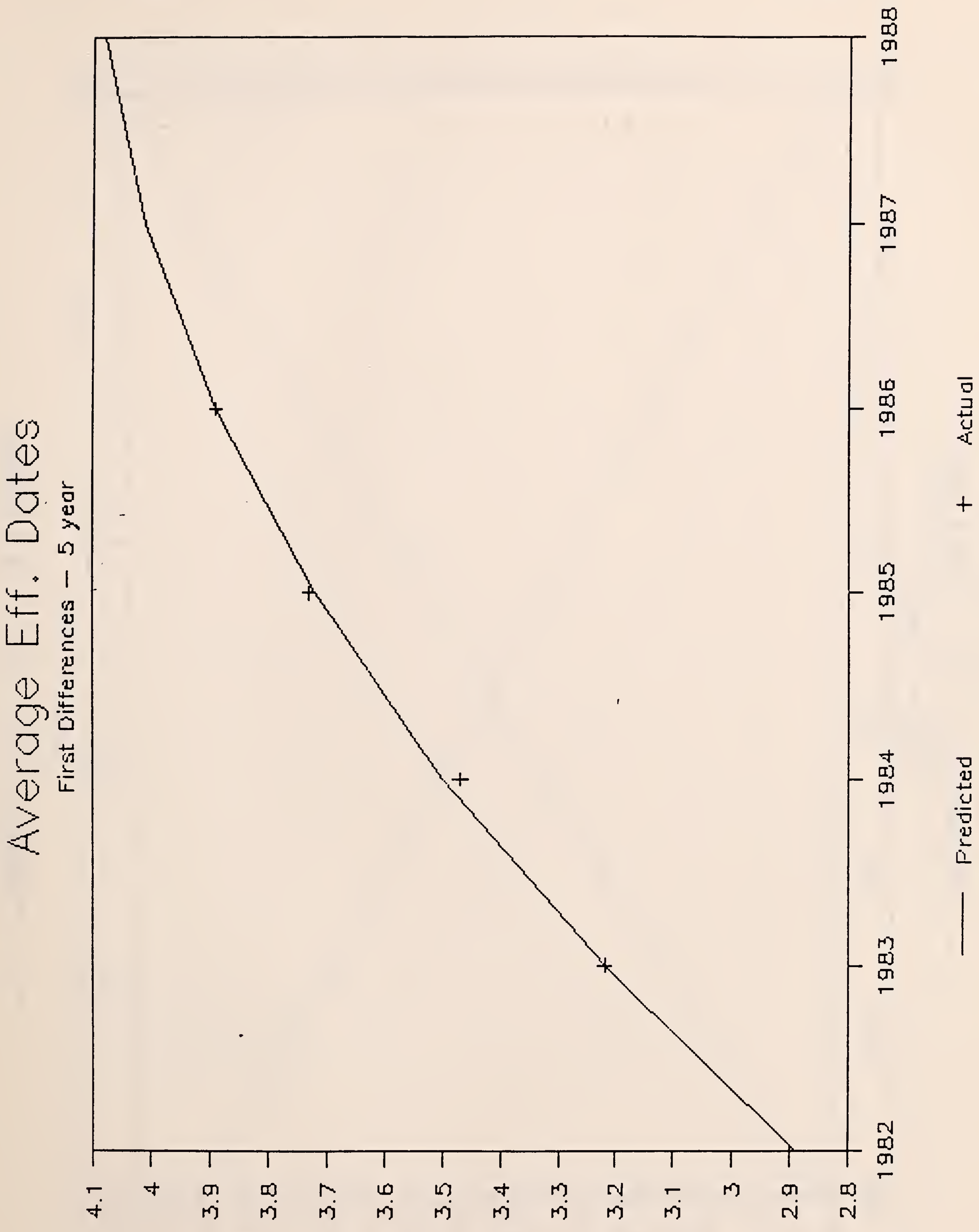
1988 AG
Exhibit 100C-9
Page 2

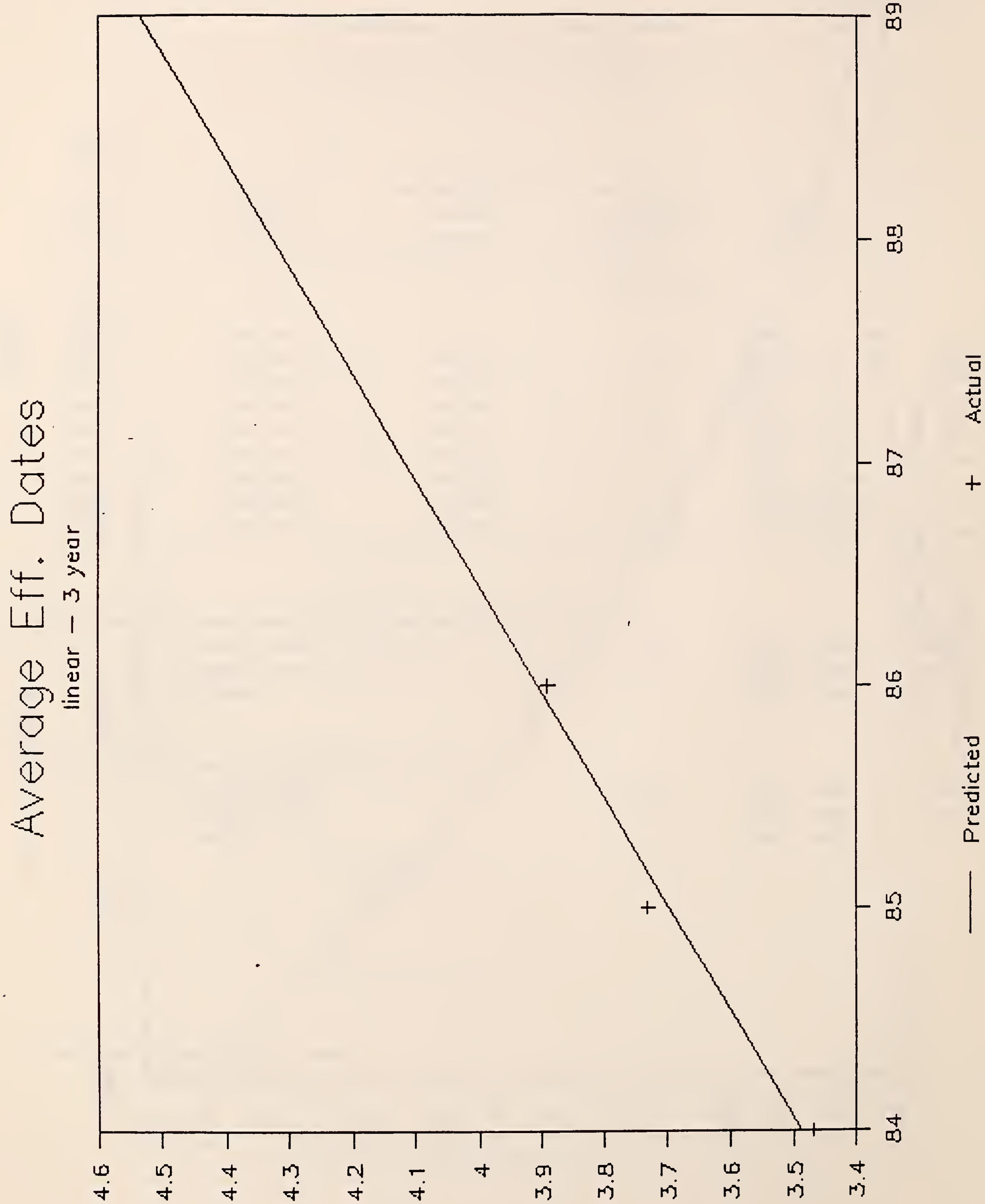
1988 Massachusetts Private Passenger Automobile
Projected Average Accident Date *

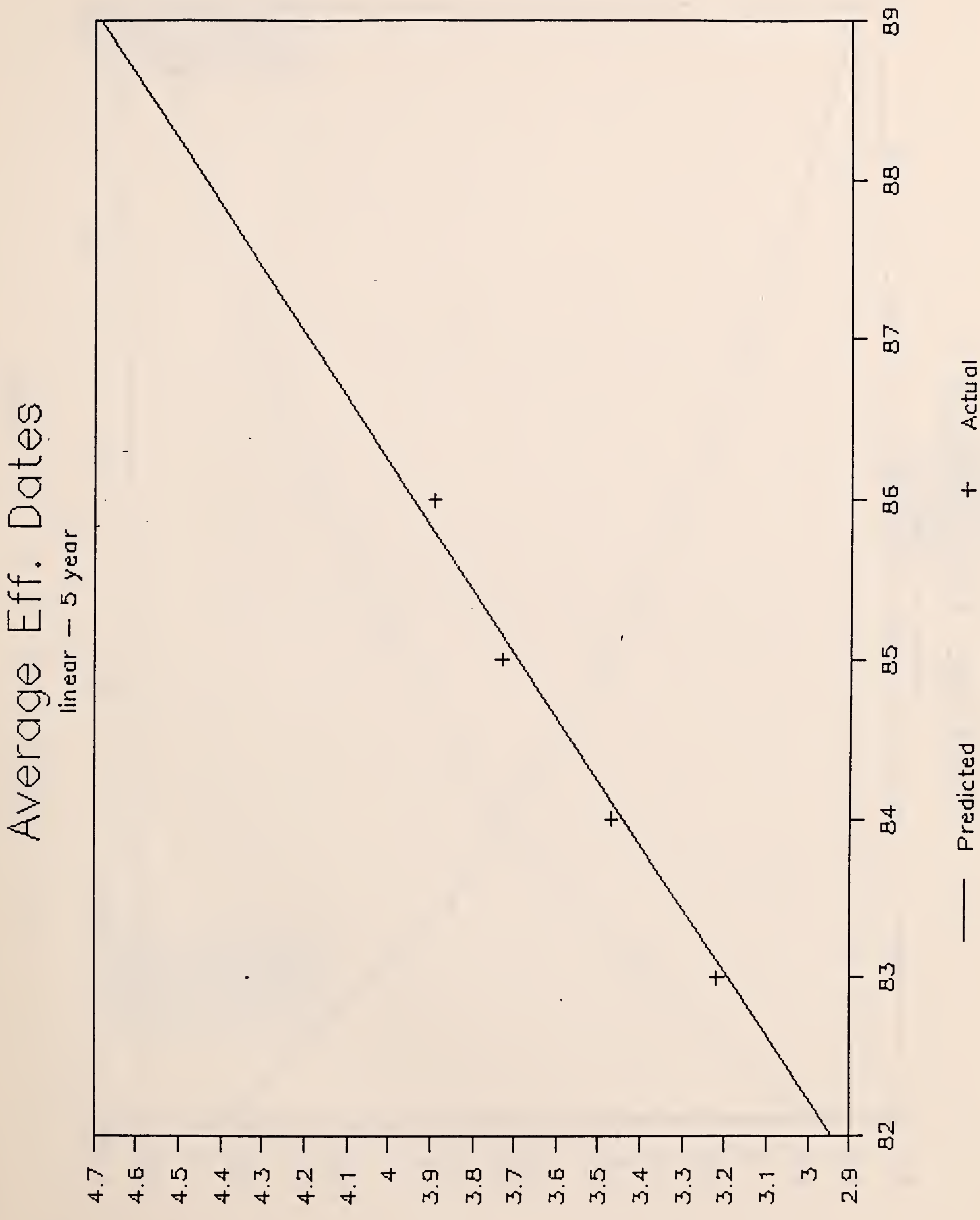
Policy Year (x)	Exposures written in year (x)	Exposures written in (x), Earned in (x+1)	Average eff. date (months after Jan.1)	Average Effective Date
(1)	(2)	(3)	(4)=12x(3)/(2)	(5)
1978	2,666,832.8	279,413.1	1.26	February 7, 1978
1979	2,729,244.9	400,147.5	1.76	February 21, 1979
1980	2,773,803.8	499,582.1	2.16	March 5, 1980
1981	2,784,980.8	581,980.6	2.51	March 16, 1981
1982	2,829,833.2	684,411.7	2.90	March 28, 1982
1983	2,894,015.0	776,647.5	3.22	April 7, 1983
1984	2,989,872.4	863,833.9	3.47	April 14, 1984
1985	3,106,282.2	964,285.1	3.73	April 22, 1985
1986	3,225,714.7	1,046,710.5	3.89	April 27, 1986

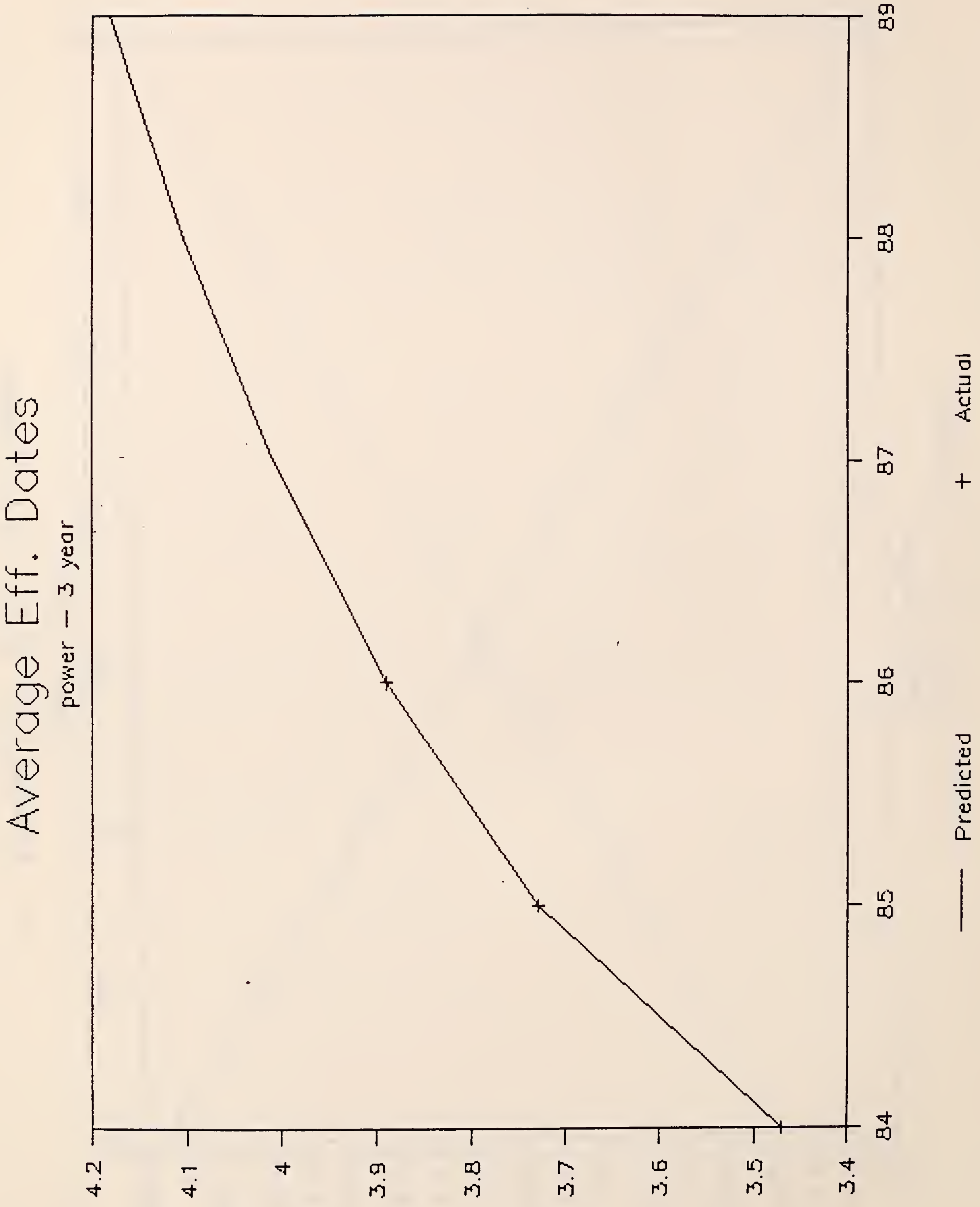
			r^2
1988 estimated by linear extrapolation (1988 MARB 100C-6)			
latest 3 years	4.33	May 10, 1988	0.9815
latest 5 years	4.44	May 14, 1988	0.9881
average		May 12, 1988	
1988 estimated by power extrapolation			
latest 3 years	4.10	May 3, 1988	1.0000
latest 5 years	4.11	May 3, 1988	0.9905
average		May 3, 1988	

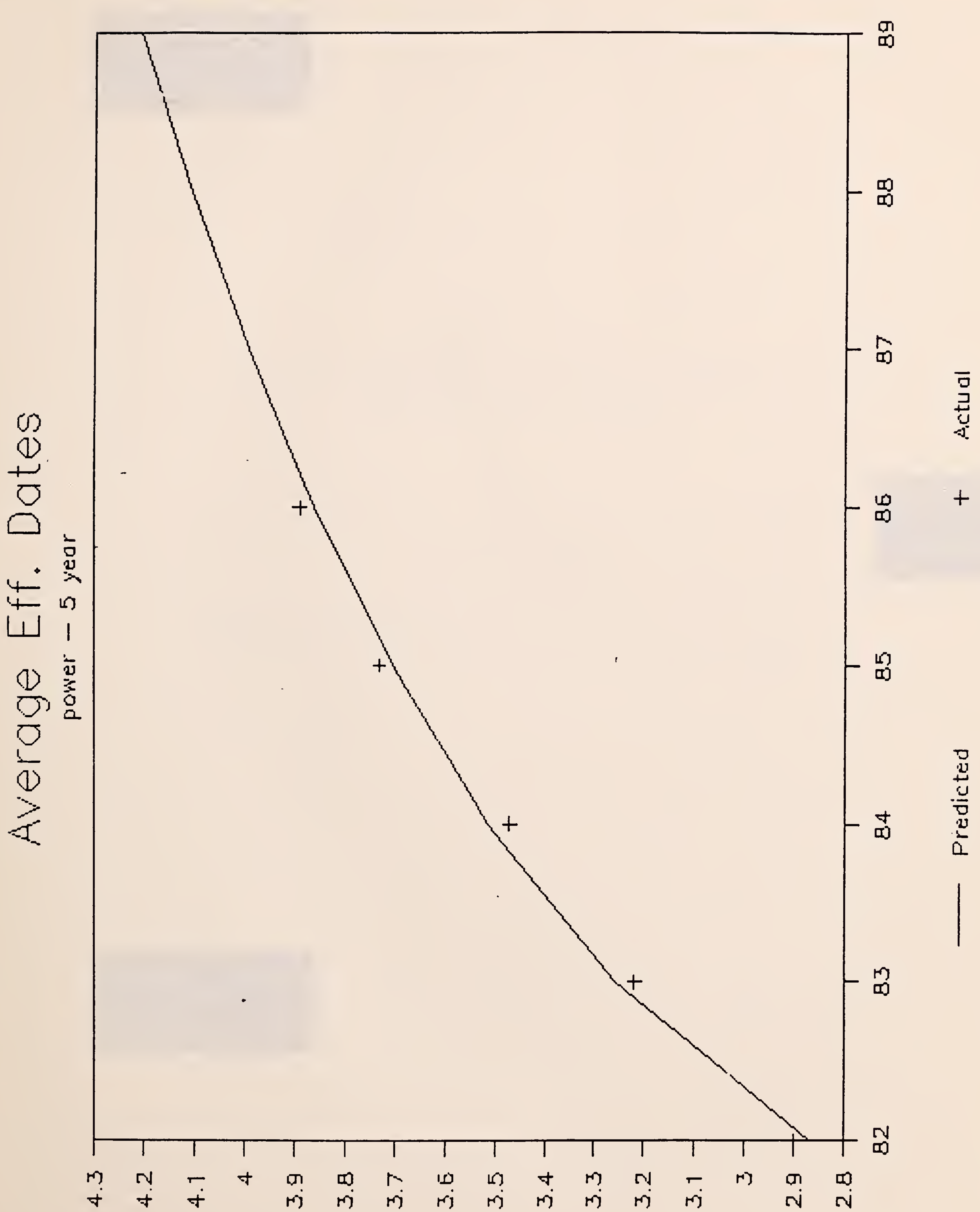
* Data from 1988 MARB, 100C-5, Page 2.


Average Eff. Dates
First Differences — 5 year
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
1982
1983
1984
1985
1986
1987
1988
Predicted
+ Actual


Average Eff. Dates
linear — 3 year
4.6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
84
85
86
87
88
89
Predicted
+ Actual


Average Eff. Dates
linear — 5 year
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
82
83
84
85
86
87
88
89
Predicted
Actual


Average Eff. Dates
power — 3 year
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
84
85
86
87
88
89
Predicted
+ Actual


Average Eff. Dates
power — 5 year
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
82
83
84
85
86
87
88
89
Predicted
Actual

[redacted]

[redacted]

[redacted]

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100D

CLAIM FREQUENCY TREND & PROJECTION FACTORS

1988 A.G.
Schedule 100D

SUMMARY OF SCHEDULE 100D

Company . . . . Attorney General

Line of Business . . . . Private Passenger

Rates Effective . . . . January 1, 1988

Claim Frequency Trend and Projection Factor

Coverage	Recommended Factor	Seatbelt Effect
A-1 10/20 Limits	.988	1.021
A-2	.988	1.021
B, Basic 10/20 Limits	.988	1.021
PDL, Basic	.924	
Collision	.989	
Limited Collision	.989	
D, Basic	.988	1.021
E, Comprehensive	.993	
U	.988	1.021

1988 A.G.
100D-1

AFFIDAVIT OF MOSHE BEN-AKIVA

I, Moshe Ben-Akiva, depose and state as follows:

1. I am employed as a faculty member in the Department of Civil Engineering at the Massachusetts Institute of Technology. I have a Bachelor of Science in civil engineering from the Technion--Israel Institute of Technology, and I have a Master's and a Ph.D. in transportation from the M.I.T. Department of Civil Engineering. I belong to several societies that are concerned with automobile transportation and traffic engineering and planning, including the Transportation Research Board, the Transportation Research Forum, the Operations Research Society of America, and the World Conference on Transportation Research Society. At M.I.T. I also teach various courses related to transportation and I do research on transportation engineering and planning topics. My primary sponsored research project at the moment at M.I.T. is sponsored by the Massachusetts Department of Public Works dealing with estimation of intersection safety improvement in Massachusetts. I also have a sponsored research project by the U.S. Department of Transportation dealing with intercity train passenger volume. I have previously testified in hearings before the Commissioner of Insurance to fix and establish the 1986 and 1987 private passenger automobile insurance rates. In those hearings I testified on behalf of the Attorney General concerning his claim frequency trend factor recommendations. A copy of my resume is attached as exhibit 100D 26.

2. I am the person primarily responsible for the preparation and presentation of section 100D Claim Frequency Trend and Projection Factors of the Attorney General's 1988 advisory filing.

3. For 1988 the Attorney General continues to follow the approach utilized by all parties and the Commissioner since 1976, that no change in claim frequency is presumed unless compelling evidence indicates a different result. This approach has been labelled the null hypothesis.

The Null Hypothesis

4. The Null Hypothesis serves as the starting point (or the maintained hypothesis) for a review of the available evidence on potential causes (or external factors) of changes in claim frequency from the experience year (1986) to the rating year (1988). A departure from the null hypothesis is acceptable only if compelling evidence exists, based on external causal factors, that indicates there will be significant changes in claim frequency from the experience year to the rating year.

5. It is my opinion that there is no reason to begin the analysis of claim frequency with the assumption that there is going to be a trend in claim frequency. I think that claim frequency is not a phenomenon which is subject to a continuous trend. A recent historical trend could be a wrong prediction of the future trend in both direction and magnitude. Therefore, I believe that it is reasonable to start the

analysis of projected claim frequency trend factors with the assumption of no change, or the so-called null hypothesis, as it has been utilized in these hearings and in past Commissioners' decisions. Thus, this year my approach on behalf of the Attorney General is to begin the analysis of claim frequency with a no change assumption and recommend upwards or downwards adjustments on the basis of external factors which can be expected to impact on claim frequency in the future.

Reconciliation of Internal Trends and the Null Hypothesis

7. While continuing to question the accuracy and resulting validity of affording any weight to extrapolations of internal frequency trends, I have attempted in this filing to explain the historical trend in terms of external factors. This analysis has led me to conclude that a methodology based on external factors can be created which will predict the general direction of future claim frequency changes. This analysis, when combined with the null hypothesis and specific, identifiable factors which will clearly impact future claim frequency, provides the Commissioner with the most comprehensive system to select claim frequency projections in these hearings.

External Methodologies

8. It is obvious that it is impossible to build a perfect model for all factors that affect claim frequency. However, this obvious observation does not imply that one must,

therefore, resort to the most imperfect method of predicting future changes by internal trend projection. The pitfalls of projecting into the future a recent historical trend are well known. It suffices to inspect the historical claim frequency data to find that past trends provide poor forecasts of future developments.

9. A recent trend can be valuable in projecting future claim frequency only if we are able to explain its underlying causes. This explanation does not have to be perfect, nor does it need to account for 100% of the changes. Random fluctuations are always present, especially in the occurrences of rare events such as traffic accidents. It is also justified to ignore minor causes that do not explain significant parts of the historical variability and are not expected to play a major role in the future.

10. Analyses of time series of accident data play an important role in highway safety research. For example, the author of a recent study of British road accident data states that:

> "[I]t is clearly of interest (and potential usefulness) to derive explanatory models of recent accident series: (a) for greater understanding of what "drives" the series and produces fluctuations; (b) in case controllable explanatory variables can be identified; (c) to provide a basis against which to evaluate further imposed changes (e.g., the seat belt wearing law.)" (Scott, P.P., "Modelling Time-Series of British Road Accident Data," Accident Analysis and Prevention, Vol. 18, No. 2, pp. 109-117, 1986, p. 109.)

11. Marked changes in historical claim or accident data can often be clearly associated with specific events such as the fuel crisis of 1973-1974 and the mandatory seat belt law. However, there are many factors that change over time at different rates with variable effects on traffic accidents. These other factors include changes in:

- o vehicle miles travelled (VMT) and travel patterns
- o gas prices
- o characteristics of the vehicle fleet such as safety standards, fuel efficiency, size, etc.
- o use of occupant restraints
- o characteristics of the highway system and its operation such as safety improvements and travel speed
- o emergency medical services
- o drunk driving programs
- o demographic shifts
- o economic conditions

12. Clearly not all these factors have significantly affected recent trends in highway accidents. For example, a recent comprehensive study by NHTSA attempted to explain the 14.4% reduction in total U.S. traffic fatalities from 1980 to 1982. (Hedlund, J., R. Arnold, E. Cerrelli, S. Partyka, P. Hoxie and D. Skinner, "An Assessment of the 1982 Traffic Fatality Decrease," Accid. Anal. & Prev., Vol. 16, No. 4, pp. 247-261, 1984.) During this period travel (i.e., VMT) increased by 1.5% in 1981 and 1.4% in 1982 and there were no significant changes in travel speeds. The authors investigated

a large number of potential explanatory factors and concluded that the 14.4% decrease:

"appears to come from:

economic effects	8-10%
alcohol	2-3%
demographics	2-3%
restraints	less than 1%"

(Hedlund, et al, p. 260)

13. Thus, the economic recession in the 1980-82 period provides the primary explanation of the decrease in traffic fatalities. The authors provide data that suggest that the changes in the economic conditions lead to shifts in the VMT distribution and a recession results in reduced driving in high risk situations (e.g., discretionary weekend/night driving by teenagers.) Thus, an overall VMT increase may mask significant shifts in driving patterns due to changes in economic factors that affect the overall traffic safety level.

14. A related study [Hedlund, J.H., "Recent U.S. traffic Fatality Trends", in L. Evans and R.C. Schwing (eds.), Human Behavior and Traffic Safety, Plenum Press, 1985.] also concluded that the 17% drop in U.S. traffic fatalities from 1980 to 1983 "can be attributed primarily to behavioral factors, not changes in vehicles, roads, or other influences. Economic conditions appear to have influenced the behavioral factors, though it is still unclear just how this influence took place."

15. The strong relationship between highway accidents and economic activity has been established in numerous studies.

1988 A.G.
100D-7

For example a recent regression analysis of 8 years of U.S. fatality counts (1975-82) produced the following equation:

$$\text{Fatalities} = 24{,}500 - 1.63 \underset{\text{(in 1000's)}}{\text{Unemployed Workers}} + .38 \underset{\text{(in 1000's)}}{\text{Employed Workers}}$$

(Partyka, S.C., "Simple Models of Fatality Trends Using Employment and Population Data," Accid. Anal. & Prev. Vol. 16, No. 3, pp. 211-222, 1984, p. 215.) These coefficients imply that a shift of 1000 workers from employed to unemployed status results in a decrease of 2.01 fatalities (1.63 + .38). This model predicts well the data during the period. It overestimates the 1982 fatalities (43,700) by only 700, clearly a small error relative to the year-to-year changes in the number of fatalities.

16. Similar results were obtained by Dr. Joksch in an analysis of the trend of motor vehicle deaths from 1930 to 1982. (Joksch, H.C., "The Relation Between Motor Vehicle Accident Deaths and Economic Activity," Accid. Anal. & Prev., Vol. 16, No. 3, pp. 207-210, 1984.) He concludes from his regression equation that:

> "one can predict the annual percentage change in traffic deaths as two-thirds of the annual percentage change of the index of Industrial Production." (Joksch, p. 210)

Dr. Joksch also states that the underlying cause for this relationship is a:

> "relatively stable, basic relations between vehicle use and the economy." (Joksch, p. 210)

Clearly, different driver groups on the highways have different levels of risks and the relationship is due to changes in the sizes of these driver subpopulations caused by the changes in the economy. Dr. Joksch also notes that:

> "there are also indications of more defensive driving during a recession." (Joksch p. 210)

17. Thus, a remarkable correlation was demonstrated between the number of motor vehicle fatalities and economic activity variables. While other factors (such as vehicle safety features, highway safety improvements, seat belts, higher speeds, emergency medical services and others) certainly had some effect on the recent trends, it is clear that the major factors have been the changes in economic activity.

18. The analyses discussed above are restricted to traffic fatalities. Analyses of non-fatal traffic injuries have been limited by severe data limitations. Every year millions of injuries occur from motor vehicle accidents; many minor injuries are unreported and a census of injuries as that of fatalities (such as the U.S. Department of Transportation Fatal Accident Reporting System) would be extremely expensive to take. The U.S. Department of Transportation established in 1979 a National Accident Sampling System that provides estimates of injuries from a two-staged sample of geographical areas and police-reported accidents. Thus, prior to 1979 there are no consistent national statistics on traffic injuries and since 1979 the year-to-year variations in the estimates of

injuries are subject to sampling errors. These data limitations are reflected in the study by the National Research Council, "55: A Decade of Experience". (Transportation Research Board, Special Report 204, Washington, D.C., 1984.) The reduction in the number of injuries attributed to the 55 MPH speed limit was estimated by assuming that the reduction in injuries on highways subject to the 55 MPH speed limit is in the same proportion as the reduction in fatalities. (See the discussion in Chapter 4 of the above cited report, pp. 75-92.) In my opinion this is a reasonable assumption and is one that I have relied on in preparing these claim frequency recommendations.

Massachusetts Experience

19. I have utilized a regression analysis based on the principles outlined above to explain the trend in claim frequency in Massachusetts. (A similar analysis for a car insurance company is described in Hautzinger, H., "Regression Analysis of Aggregate Accident Data: Some Methodological Considerations and Practical Experiences," Accid. Anal. & Prev., Vol. 18, No. 2, pp. 95-102, 1986.)

20. There are three basic approaches for predicting future claim frequencies that have been suggested in these proceedings in the past:

- Pure trend extrapolation-future claim frequencies are based solely on historical trends, no attempt is made to explain why changes in frequencies are occurring (this approach corresponds to that used by MARB in its 1987 and 1988 rate filings);

- o <u>Structural approach</u>-relationships are developed between claim frequencies and explanatory variables, forecasts of future claim frequencies are made based on changes in these explanatory variables;

- o <u>Mixed structural/trend approach</u>-future claim frequencies are based on both historical trends and changes in explanatory variables.

21. In view of the problems associated with reliance on trend projections from historical data, and the importance of explanatory variables such as economic factors, I feel that it is crucial to forecast claim frequency based on forecasts of external factors. To provide these forecasts, I have analyzed the trend data in an attempt to relate claim frequencies to external factors. The resulting regression equations were then applied to develop a <u>range</u> of predictions of future claim frequencies.

<u>Description of the Regression Analysis</u>

22. The regression equations that were estimated represent the three alternative forecasting approaches:

- o Structural approach
- o Mixed structural/trend approach
- o Pure trend approach

With the structural approach, changes in claim frequencies are related to changes in external factors. The regression equations developed for this filing relate the percent change in claim frequency between periods t and t-1 to percentage changes in gasoline price, unemployment rate and ratio of total exposures and the working age population.

23. In this year's filing, I have extended the regression equations used last year in the Attorney General's filing in two aspects:

- The estimation is performed using quarterly claim frequencies derived from the statistical plan data, thereby increasing significantly the number of observations relative to the annual data which was used last year.

- The ratio of total exposures and the working age population has been added as a third external factor to capture the effects of increasing personal income and vehicle ownership levels. This variable is calculated as the ratio of exposures for A-1 and B to the working age population in Massachusetts and may be interpreted as car availability per driving age person. A priori, car availability was expected to have a negative effect on frequency, since each car is driven less as the number of cars per household increases. In the regression results, car availability proved to carry a negative coefficient in certain specifications, and a positive one in others. A positive sign may indicate that the increases in car availability are occurring mostly for younger inexperienced drivers, resulting in increased claim frequency.

24. The form of the regression equations is based on the following first order approximation. Consider a model of claim frequency with three explanatory variables denoted by:

$$f = F(x_1, x_2, x_3)$$

where

f = claim frequency;

x_1, x_2, x_3 = explanatory variables; and

$F(\cdot)$ = the unknown functional form of the model.

This model can be approximated by the following linear form:

$$\Delta f = a_1 \Delta X_1 + a_2 \Delta X_2 + a_3 \Delta X_3$$

where

Δf = change in a base value of claim frequency;

ΔX_1, ΔX_2, ΔX_3 = changes in base values of the explanatory variables; and

a_1, a_2, a_3 = partial derivatives of $F(\cdot)$ with respect to the explanatory variables X_1, X_2 and X_3, respectively.

Divide both sides of the above equation by f and multiply each of the three terms on the right hand side by $\frac{X_1}{\overline{X}_1}$, $\frac{X_2}{\overline{X}_2}$, $\frac{X_3}{\overline{X}_3}$, respectively; to obtain the form of the regression equations.

$$\frac{\Delta f}{f} = b_1 \frac{\Delta X_1}{\overline{X}_1} + b_2 \frac{\Delta X_2}{\overline{X}_2} + b_3 \frac{\Delta X_3}{\overline{X}_3}$$

where

$\frac{\Delta f}{f}$ = percent change in claim frequency;

$\frac{\Delta X_1}{X_1}$, $\frac{\Delta X_2}{X_2}$, $\frac{\Delta X_3}{X_3}$ = percent changes in the explanatory variables;

$$b_1 = a_1 \frac{X_1}{f}$$

$$b_2 = a_2 \frac{X_2}{f}$$

$$b_3 = a_3 \frac{X_3}{f}$$

The coefficients b_1, b_2, and b_3 are called elasticities. For example, b_1 expresses the percentage change in frequency due to a 1% change in X_1. This is the form of the Attorney General's regression equations.

25. The Attorney General's claim frequency regression equations can be interpreted as first order approximations of an unspecified model. They predict the percent change in claim frequency as a linear function of the percent changes in the explanatory factors (i.e., gas price, unemployment rate and the exposure ratio.)

26. The percent changes in claim frequency are calculated on an annual basis between the same quarters. For example the value for the 3rd quarter of 1985 is the percent change from the 3rd quarter of 1984. The explanatory variables are also year-to-year changes in the quarterly values. In explaining the change in claim frequency for a given quarter it is possible to include both contemporaneous changes and changes in previous quarters in the explanatory variables. For example, a lagged gasoline price variable represents the delayed effect on frequency of a gasoline price change while an unlagged gasoline price change measures the immediate response.

27. In applying the structural approach in forecasting, changes in claim frequencies are predicted solely as a function of changes in explanatory variables; no reliance is placed on

unexplained internal trends. This forecasting approach corresponds to explicit consideration of departures from the null hypothesis referred to in this and previous filings.

28. With the mixed structural approach, changes in claim frequencies are expressed as a function of both changes in external factors and unexplained historical trends.

29. The unexplained internal trend approach can be represented by a constant trend (expressed as an annual percentage change) and lag dependent variables representing the percentage changes in claim frequencies occurring in earlier periods.

30. Separate regression equations were estimated for A-1 and B, PDL, and Collision claim frequencies using a structural specification, a mixed structural/trend approach and a pure trend approach. These equations were estimated with quarterly claim data obtained from the MARB. In order to construct quarterly claim frequencies, quarterly exposures were calculated by interpolating annual exposure data taken from the MARB filing. Different methods were tried and a quadratic interpolation method that produced the most reasonable quarterly series was chosen.

31. The data used to estimate the coefficients include the following:

- Historical quarterly claim counts (developed to ultimate) between 1977 and 1986 from MARB's 1988 filing, Section 100C-8.

- o Historical exposures between 1977 and 1986 from MARB's 1988 filing, Section 100B-1.
- o Boston area gasoline prices (in constant dollars) from the Bureau of Labor Statistics. (AG Exhibit 100D-1)
- o Monthly Massachusetts unemployment rate from the Massachusetts Division of Employment Security between 1976 and 1986. (AG Exhibit 100D-2)
- o Working age population figures for Massachusetts from the Massachusetts Division of Employment Security. (AG Exhibit 100D-2)

32. The historical claim frequency change data for A-1 and B were adjusted to account for the tort threshold effect and the Bilodeau effect using the adjustments calculated by MARB in its filing. Frequency data for PDL, Collision and A-1 and B were adjusted for seatbelt and brakelight effects. The Attorney General's calculations of the brakelight effect is different from MARB's and is explained in a separate section. Boston area gasoline prices are presented in Exhibit 100D-1. Massachusetts working age populations and unemployment data are presented in Exhibit 100D-2. The development of claim frequency changes are presented in Exhibits 100D-3 through 100D-5.

33. The coefficient values for these regression equations were estimated using ordinary least squares. Estimation results are presented in Exhibits 100D-6 through 100D-8. Graphs of predicted versus historical changes in claim frequencies are presented in Exhibits 100D-9 through 100D-17.

Forecasts

34. Each of the regression equations were used to predict a range of possible future changes in claim frequencies between

1986 and 1988. The equations were applied to three scenarios representing various assumptions about changes in the price of gasoline, the unemployment rate and car availability in Massachusetts that will occur over this period.

35. Scenario 1 represents a situation in which gasoline prices, unemployment and car availability remain at their 1986 levels during 1987 and 1988.

36. Scenario 2 assumes the continuation of existing trends. With respect to gasoline price, an increasing trend is apparent during the first six months of 1987. For Scenario 2, gasoline price continues to increase during 1987 and begins to taper off in 1988, resulting in a 16% change in 1987 followed by an 8% change in 1988. The unemployment rate, which has remained relatively stable during 1985 and 1986, is assumed to remain at an annual average rate of 3.8% during the entire forecast interval. Car availability, which increased at a rate of approximately 3% during recent years, is assumed to grow by 1% annually during 1987 and 1988. The recent car ownership growth due to increasing incomes and employment is unlikely to persist during the forecast period under stable economic conditions.

37. Scenario 3, in contrast, assumes that unemployment and gasoline prices will return to their 1984 levels at the end of 1988. The price of gasoline, therefore, increases by 5% per quarter during the forecast interval so that at the end of 1988 it has reached the 1984 level. Unemployment remains stable in

1987 and returns in 1988 to the 4.8% level of 1984. Car availability is again assumed to increase by 1% annually as in Scenario 2.

38. These percent changes in the three economic factors assumed for the three scenarios are summarized in the following table.

	Scenario 1 No Change	Scenario 2 Recent Trends	Scenario 3 1984 Values in 1988
Annual % Change			
Gasoline Price			
1987	0	16%	20%
1988	0	8%	20%
Unemployment Rate			
1987	0	0%	0%
1988	0	0%	26%
Car Availability			
1987	0	1%	1%
1988	0	1%	1%

39. Three different scenarios were presented. It is impossible to predict precisely what will happen to those economic factors from 1986 through 1988. However, it is useful to present a range of reasonable possibilities of the likely changes which is what these scenarios represent.

40. The results of the forecasts based on these scenarios are summarized below:

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Percent Change in Claim Frequencies
1986-1988

Coverage	Scenario 1 No Change	Scenario 2 Recent Trends in 1988	Scenario 3 1984 Values
A-1 & B			
Structural	0	+1.0	-2.9
Mixed	+3.5	+7.3	+3.7
Trend	+6.6		
PDL			
Structural	0	-8.4	-11.6
Mixed	+2.9	-4.8	-7.6
Trend	-3.8		
Collision			
Structural	0	-2.4	-3.8
Mixed	+8.8	+8.6	+9.4
Trend	+9.1		

Conclusion

41. The above regression equations and forecasts have confirmed the observations from the traffic safety research literature reported earlier about the strong relationship between accidents and economic activity.

42. The range of future scenarios that were analyzed are based on the following considerations which I believe to be reasonable.

- o Gasoline Price and Unemployment Rate: I did not find compelling evidence to support the possibility that these factors will decrease during the forecast period. Thus, the effect of the likely changes in these factors can only be to decrease claim frequencies for the major coverages.

- o Car Availability: The historical trend of the car availability factor and the nature of this variable indicate that it is likely to continue to increase during the forecast period. This would cause an increase of BI claim frequency and a decrease of PDL frequency.

43. These considerations imply a prediction of decreasing PDL and Collision claim frequencies due to the economic factors. The direction of the change of BI frequency depends on the relative magnitudes of the likely decrease due to gasoline price and unemployment and the likely increase due to growth in car availability.

44. The structural approach is the approach that I think should be followed in these hearings. The purpose of the structural approach is to explain the changes in the internal trend as a function of changes in external factors. The structural approach does not place any reliance on the unexplained internal trend and it explicitly considers those external factors or causal factors that can be used to justify the departure from the null hypothesis.

45. I do not recommend that the Commissioner apply the mixed approach or the pure trend approach. Both of these approaches rely on the trending of historical data. Reliance on such data without being able to explain the reasons for the movements in the data is not a reasonable approach to claim frequency projection.

46. If the trending of unexplained historical data is relied upon and the underlying causal factors have changed, projected claim frequencies will be wrong in direction or magnitude. The erratic nature of the historical frequency data shown in Exhibits 100D-3, 4 & 5 indicate the dangers of

significant errors in prediction if a projected trend were chosen relying on either the trend or the mixed methods.

47. I included the mixed & trend approaches to show the impact of the trend factors on the regression equation. I included the trend approach to indicate what the results would be of a trend derived from historical data without the use of any judgmental factors or weights.

48. My recommendations for claim frequency projections are based on the range of predicted changes obtained by the structural equations. The conclusion that I derived is that there is no compelling evidence to reject the null hypothesis for the forecast from '86 to '88 - except for PDL coverage. The regression analysis confirmed what we already knew from the literature - that there is a relationship between the economy or employment and gasoline price and accidents - and quantified the relationship with the data that we had on claim frequency. Then, given the established relationship and given the anticipated changes in the unemployment rate and gasoline price, this analysis also indicates a range of changes in the direction of the trend in claim frequency. However, given the uncertainty in a prediction of the unemployment rate, the gasoline price and the exposure ratio, and given that there are other uncertainties in these regressions, I recommend the use of the null hypothesis for these coverages except PDL.

49. I will summarize my recommendations as follows:

o <u>BI</u>

The range of predicted values is from -2.9 to +1.0. This indicates that the increasing effect of car availability is likely to be compensated by increasing gas price. Therefore, I do not find any compelling evidence to depart from the null hypothesis for the BI coverages including the A2, D and U coverages.

o <u>PDL</u>

The predicted changes range from 0 to -11.6. All the factors point in the same direction and the changes predicted are quite large. I find that these results provide compelling evidence for a departure from the null hypothesis. The range of likely decreases is quite wide, making it highly likely that a decrease will occur, but also making it difficult to select a point estimate. Therefore, I recommend that the mid-point, -5.8% be used.

o <u>Collision& Limited Collision</u>

The range of predicted changes is entirely negative as for PDL. Thus, a decrease in collision claim frequency is most likely. However, the range is significantly narrower, from 0 to -3.8. I find that these results do not provide sufficiently strong evidence to depart from the null hypothesis.

Based on these results, I recommend that the following claim frequency trends be used to represent the effects of changes in economic activity and gasoline prices between 1986 and 1988:

A-1, A2, B, D & U	0.0%
PDL:	-5.8%
Collision & Limited Collision:	0.0%

I accept the MARB's recommendation of no trend for the comprehensive coverage.

APPLICATION OF RECENT EXTERNAL PHENOMENON

50. The Attorney General has identified three recent external factors which will have an impact on future claim frequency trends. These factors are related to the repeal of the seatbelt law, high center mounted brake lights, and the impact of Chapter 44 of the Acts of 1987 on auto arson.

Repeal of the Seat Belt Law

51. In its filing for 1988 rates, MARB has included a 3.7% increase in Bodily Injury loss costs to account for the repeal of the seatbelt law on December 4, 1986. The methodology and assumptions used by MARB in arriving at this figure are the same as those used in last year's decision except for the post-repeal usage rates. I concur with the general methodology used by MARB, but do not accept MARB's estimate for the usage rate during policy year 1988.

52. The results of a survey conducted by Boston

University just after the seat belt law was repealed indicated a seat belt usage rate of 24%. For policy year 1988, MARB assumed that seat belt usage would be approximately halfway between the pre-law rate (17%) and the observed post-repeal rate (24%). There appears to be no basis for this assumption, and therefore I believe that the best estimate of seatbelt usage in policy year 1988 is that observed in the post-repeal survey (24%).

53. In addition to examining changes in overall seat belt usage, I feel that it is important to consider the distribution of these changes as well. For example, based on the survey results for post-law and post-repeal usage rates for dry versus wet pavement conditions (see 1988 MARB Section CD, Exhibit 3, page 5), belt use under dry road conditions decreased from 37% post-law to 24% post-repeal. Under wet road conditions, however, belt usage after repeal remained at the same general high level (49%) as that observed post-law (46%). Since accident rates are likely to be higher under wet road conditions, this difference must be accounted for in estimating the increase in bodily injury loss costs attributable to the repeal of the seat belt law.

54. To do this I first calculated the average expected increase in injury loss costs separately for dry and wet road conditions (see Exhibits 100D-18 and 100D-19 respectively.) Under dry road conditions, the expected increase in loss costs

is 2.8%, based on a post-law usage rate of 34% and a post-repeal rate of 24%. Under wet road conditions, since belt use remains constant, there is no increase in loss costs.

55. The overall average increase in loss costs is a weighted average of these loss costs, with the weight being given by the proportion of bodily injury accidents occurring under dry and wet road conditions, respectively. These proportions were calculated using accident experience data for 1980 provided by the Registry of Motor Vehicles (see Exhibit 100D-20.) As shown in Exhibit 100D-21, I recommend that the overall average increase in bodily injury loss costs attributable to the repeal of the seat belt law is best estimated to be 2.1%.

Impact of High-Mounted Center Brake Lights

56. In its filing for 1988 rates, MARB included an analysis of the impact of high-mounted center brake lights that resulted in estimated savings of 1.5% for PDL, 0.5% for collision, and 0.4% for Bodily Injury (see 1988 MARB, 100CD-5, Exhibit 1.) This analysis was based on the model from last year's decision with the following modifications:

(1) The percentage reduction in the incidence of relevant rear-end collisions when the leading car is equipped with a high-mounted center brake light used in the analysis was based on a new study by the U.S. Department of Transportation.[1]

1/ Kahane, C.J., "The Effectiveness of Center Mounted Stop Lamps: A Preliminary Evaluation," prepared for U.S. Department of Transportation, Mar. 1987. (See p. 234 of 1988 MARB Filing.)

(2) The percentage of vehicles on the road in 1988 that will be equipped with a high-mounted center brake light was estimated using updated information on the underlying survival rates of automobiles obtained from a more recent edition of ORNL's Transportation Energy Databook.

57. I concur with MARB's use of the same model used in last year's decision, and with the use of updated information on automobile survival rates. However, I cannot accept the use of results from the new USDOT study to estimate the percentage reduction in the incidence of rear-end collisions. Many of the assumptions used in the model are based on an earlier USDOT study by Reilly, et al.[2] Because the methodology used in the Kahane study is different from that used in the Reilly study, the results of these two studies are not comparable. Specifically, the Reilly study is based on all accidents reported by the drivers of fleet vehicles, regardless of the extent of damage. The Kahane study is based on police reported accidents, which exceed some minimum damage criterion, usually at least several hundreds of dollars. In other words, the results of the Reilly study represent all relevant rear-end collisions, while the results of the Kahane study are representative of a subset of the more severe accidents relevant to rear-end collisions.

2/ R.E. Reilly, D.S. Kurke, C.C. Buckenmaier, "Validation of the Reduction of Rear-End Collisions by a High Mounted Auxiliary Stoplamp," prepared for U.S. Department of Transportation, May 1980. (See AG Exhibit 100D-25.)

58. The problem in using the Kahane study results in conjunction with the model used in last year's decision is related to the factor representing the severity of rear-end collisions relative to all accidents. This factor is based on the Reilly study and is calculated as the average repair cost for relevant rear-end collisions observed in the Reilly study for cars without high mounted center brakelights ($314) divided by the average paid claim cost in 1979 for Massachusetts ($559).

59. Since the Kahane study included only more severe rear-end collisions, it is clearly inappropriate to use the results of this study in conjunction with the severity factor calculated from the Reilly study.

60. Since there are no claim cost data available with the Kahane study, I continue to rely upon the Reilly study for the percentage reduction in the incidence of relevant rear-end collisions to estimate the impact of high-mounted center brakelights on PDL and Collision. Using the results from the Reilly study, I estimate the following change in loss costs (see Exhibit 100D-22.)

PDL: -1.8%

Collision: -1.1%

61. I accept MARB's use of the Kahane study results for Bodily Injury. However, it should be noted that this estimate is based on the reduction in the number of rear-end collisions only. It does not account for the reduction in bodily injury claims that would be attributable to the reduced severity of

rear-end collisions that would still occur. If the reduction in severity of bodily injury is assumed to be proportional to that observed for PDL in the Reilly study (i.e., 57%), the resulting change in bodily injury pure premium would be 1.2% (see Exhibit 100D-23.) Therefore, I recommend that a downward change of -1.2% be applied to bodily injury coverages for the impact of the brake lights.

Impact of Chapter 44 on Auto Arson

62. Chapter 44 of the Acts of 1987 requires an insured to complete a written statement before payment is made on a theft or fire claim. This is similar to the procedure developed by the City of Cambridge, which began vigorously investigating auto fires in 1983. As a result of its investigation and prosecution efforts, auto arson has been reduced substantially in the City of Cambridge. The Attorney General feels that Chapter 44 can have a similar effect on a statewide basis.

63. The reduction in car fires experienced by the City of Cambridge is presented in Exhibit 100D-24. As shown, prior to initiating investigation efforts at the end of 1982, there was an average of 39.9 car fires per month. In 1983, this had dropped to 9.7 car fires per month, a decrease of 75.7%. Since the Cambridge investigation efforts were more intense than those required by Chapter 44, I have judgementally assumed that Chapter 44 will be half as effective at reducing car fires as the City of Cambridge. Specifically, I assumed that car fire

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claims will be reduced by 37.8% as a result of Chapter 44. Based on information in 1988 MARB Section 100D-3, Exhibit 2, page 1, fire claims represented 1.77% of all comprehensive claims in 1986 (4,244/240,121). A 37.8% reduction in fire claims, therefore, represents a 0.7% reduction in total comprehensive claim frequency.

Recommendations

64. Based on my analysis of the relevant data presented in this section, I recommend on behalf of the Attorney General the following claim frequency trend factors for the period 1986-88.

		Trend Factor			
Coverage	Regression Factor	Brake-lights	Seatbelts	Chapter 44	Total (including seatbelts)
Bodily Injury (A-1, A-2 B, D & U)	0.0%	-1.2%	+2.1%		+0.8%
PDL	-5.8%	-1.8%			-7.6%
Collision & Limited Collission	0.0%	-1.1%			-1.1%
Comprehensive				-0.7%	-0.7%

Signed under the pains and penalties of perjury this 2nd day of September, 1987.

Moshe Ben-Akiva

Moshe Ben-Akiva

U.S. Bureau of Labor Statistics

Consumer Price Index (CPI-W)
Urban Wage Earners and Clerical Workers
U.S. City Average
All items
1967=100

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	175.3	187.1	204.7	233.3	260.7	282.1	292.1	302.7	312.6	324.3	327.7
February	177.1	188.4	207.1	236.5	263.5	282.9	292.3	303.3	313.9	323.2	329.0
March	178.2	189.7	209.3	239.9	265.2	282.5	293.0	303.3	315.3	321.4	330.5
April	179.6	191.4	211.8	242.6	266.8	283.7	294.9	304.1	316.7	320.4	332.3
May	180.6	193.3	214.3	245.1	269.1	286.5	296.3	305.4	317.8	321.4	333.4
June	181.8	195.3	216.9	247.8	271.4	290.1	297.2	306.2	318.7	323.0	334.9
July	182.6	196.7	219.4	248.0	274.6	291.8	298.2	307.5	319.1	322.9	
August	183.3	197.7	221.5	249.6	276.5	292.4	299.5	310.3	319.6	323.4	
September	184.0	199.1	223.7	251.9	279.1	292.8	300.8	312.1	320.5	324.9	
October	184.5	200.7	225.6	254.1	279.7	293.6	301.3	312.2	321.3	325.0	
November	185.4	201.8	227.6	256.4	280.4	293.2	301.4	311.9	322.6	325.4	
December	186.1	202.9	230.0	258.7	281.1	292.0	301.5	312.2	323.4	325.7	
Annual Average	181.5	195.3	217.7	247.0	272.3	288.6	297.4	307.6	318.5	323.4	

Massachusetts Private Passenger Automobile
Boston Gasoline Prices for One Gallon of Gasoline - All Types

	1977*	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	58.4	62.5	68.4	110.4	126.5	134.8	122.7	117.5	114.7	121.4	85.7
February	59.7	61.9	69.8	118.2	135.5	132.9	119.6	117.0	113.0	118.1	89.3
March	60.5	62.0	72.5	122.2	138.7	127.9	115.4	118.1	114.2	106.4	89.7
April	61.2	62.5	76.8	123.1	138.3	120.0	119.2	117.8	116.1	92.4	91.6
May	62.2	62.9	80.8	122.9	137.4	119.4	122.3	117.6	119.0	90.5	92.7
June	62.3	63.7	86.9	122.1	137.2	125.8	123.8	116.8	120.8	94.3	94.3
July	62.6	64.6	92.8	122.2	136.3	128.8	124.9	115.8	121.8	91.3	
August	62.6	65.5	97.2	123.1	135.8	128.5	122.8	115.2	121.9	82.9	
September	62.7	66.0	99.6	122.2	137.1	128.3	122.6	115.5	121.1	84.5	
October	62.7	65.9	100.4	122.5	136.6	127.4	122.2	115.6	120.6	84.1	
November	62.6	66.5	100.7	122.2	136.1	126.4	121.3	115.3	121.3	84.3	
December	62.6	67.4	102.8	122.9	135.8	125.3	118.9	114.7	121.6	84.4	
Annual Average	61.7	64.3	87.4	121.2	135.9	127.1	121.3	116.4	118.8	94.6	

Massachusetts Division of Employment Security

Massachusetts Unemployment Rate
Seasonally Adjusted

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	8.9	6.2	6.4	5.4	5.4	7.0	7.8	6.5	3.8	3.4	3.5
February	8.8	6.3	5.9	5.1	5.7	7.7	7.6	5.8	3.9	3.8	3.5
March	8.5	5.9	6.4	5.0	5.7	7.1	7.5	5.3	4.2	3.8	3.9
April	9.3	6.1	5.7	5.5	5.5	8.3	7.0	5.3	3.9	4.0	4.0
May	6.9	5.7	5.2	6.1	5.9	8.7	6.8	4.3	3.8	4.4	3.7
June	7.7	6.8	4.8	6.3	5.9	8.7	7.2	4.3	3.9	3.7	
July	7.8	6.3	4.8	6.0	6.5	9.6	6.2	4.3	4.3	3.8	
August	8.9	6.4	4.4	5.9	7.3	7.9	6.2	5.0	3.9	3.9	
September	9.2	5.9	6.5	6.0	6.7	7.3	6.9	4.3	3.7	4.0	
October	7.6	5.1	5.1	6.2	7.2	7.6	6.9	3.8	3.8	3.9	
November	7.4	5.8	5.5	5.3	7.2	7.3	6.3	4.0	4.0	4.0	
December	6.5	6.3	5.6	4.8	7.3	7.5	6.1	4.2	4.1	3.3	
Annual Average	8.1	6.1	5.5	5.6	6.4	7.9	6.9	4.8	3.9	3.8	

Massachusetts Working Age Population
Seasonally Unadjusted

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
January	4234	4277	4320	4357	4399	4433	4457	4493	4524	4544	4563
February	4238	4281	4324	4359	4403	4434	4460	4497	4526	4545	4565
March	4242	4285	4328	4362	4407	4436	4462	4501	4527	4547	4567
April	4245	4288	4331	4364	4410	4438	4465	4504	4529	4549	4568
May	4249	4292	4335	4368	4414	4440	4467	4508	4530	4551	4570
June	4252	4295	4338	4372	4418	4441	4470	4511	4532	4552	4571
July	4256	4299	4342	4376	4422	4443	4472	4515	4533	4554	
August	4260	4303	4344	4379	4424	4443	4476	4517	4535	4554	
September	4263	4306	4347	4383	4426	4448	4479	4518	4537	4555	
October	4267	4310	4349	4387	4427	4450	4483	4520	4538	4557	
November	4270	4313	4352	4391	4429	4453	4486	4521	4540	4557	
December	4274	4317	4354	4395	4431	4455	4490	4523	4542	4559	
Annual Average	4254	4339	4297	4418	4374	4472	4443	4532	4511	4552	

A-1 & B Coverage

	Claim Counts	Exposures	4 x C/E Frequency	Annual Frequency Change	Tort Effect	Bilodeau Effect	Brakelight Effect	Seatbelt Effect	Adjusted Frequency Change
1977:1	6940	2455460	1.13						
2	6860	2453174	1.12						
3	7318	2454880	1.19						
4	8256	2460578	1.34						
1978:1	6339	2470309	1.03	-9.21	-2.1				-11.31
2	6835	2483994	1.10	-1.60	-2.1				-3.70
3	7491	2501673	1.20	0.45	-2.1				-1.6[illegible]
4	7934	2523344	1.26	-6.29	-2.1				-8.39
1979:1	6828	2566409	1.06	3.68	-2.0				1.68
2	7866	2589164	1.22	10.41	-2.0				8.41
3	8115	2608967	1.24	3.87	-2.0				1.87
4	8508	2625816	1.30	3.05	-2.0				1.05
1980:1	6766	2637275	1.03	-3.57	-1.9				-5.4[illegible]
2	8181	2649177	1.24	1.65	-1.9				-0.25
3	7975	2659088	1.20	-3.58	-1.9				-5.48
4	8790	2667008	1.32	1.72	-1.9				-0.18
1981:1	7536	2663760	1.13	10.27	-1.8	-0.7			7.77
2	8104	2671361	1.21	-1.76	-1.8	-0.7			[illegible]
3	8778	2680641	1.31	9.18	-1.8	-0.7			[illegible]
4	9668	2691598	1.44	8.98	-1.8	-0.7			6.48
1982:1	7691	2707656	1.14	0.40	-1.7	-0.7			-2.00
2	8421	2720610	1.24	2.03	-1.7	-0.7			-0.37
3	8757	2733879	1.28	-2.18	-1.7	-0.7			-4.58
4	9734	2747462	1.42	-1.36	-1.7	-0.7			-3.76
1983:1	8323	2756064	1.21	6.32	-1.6	-0.7			4.02
2	9599	2772394	1.38	11.86	-1.6	-0.7			9.56
3	9810	2791162	1.41	9.73	-1.6	-0.7			7.43
4	10568	2812368	1.50	6.06	-1.6	-0.7			3.76
1984:1	9394	2840931	1.32	9.50	-1.5	-1.4			6.60
2	10504	2865072	1.47	5.89	-1.5	-1.4			2.99
3	11139	2889698	1.54	9.68	-1.5	-1.4			6.78
4	11974	2914810	1.64	9.32	-1.5	-1.4			6.42
1985:1	10631	2938302	1.45	9.42	-1.4	2.5			10.52
2	11782	2965230	1.59	8.38	-1.4	2.5			9.48
3	11868	2993493	1.59	2.85	-1.4	2.5			3.95
4	13096	3023091	1.73	5.45	-1.4	2.5			6.55
1986:1	10181	3054058	1.33	-7.86	-1.3	1.0	0.3	4.5	-3.36
2	12812	3086326	1.66	4.48	-1.3	1.0	0.3	4.5	8.98
3	12987	3119929	1.67	4.99	-1.3	1.0	0.3	4.5	9.49
4	13003	3154867	1.65	-4.86	-1.3	1.0	0.3	4.5	-0.36

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Exhibit 100D-4

PDL Coverage

	Claim Counts	Exposures	4 x C/E Frequency	Annual Frequency Change	Brakelight Effect	Adjusted Frequency Change
1977:1	60426					
2	44485					
3	46901					
4	60466					
1978:1	62854	2470309	10.18			
2	48502	2483994	7.81			
3	50862	2501673	8.13			
4	61268	2523344	9.71			
1979:1	55724	2566409	8.69	-14.66		-14.66
2	53193	2589164	8.22	5.22		5.22
3	50974	2608967	7.82	-3.90		-3.90
4	58278	2625816	8.88	-8.59		-8.59
1980:1	50504	2637275	7.66	-11.80		-11.80
2	52970	2649177	8.00	-2.68		-2.68
3	49929	2659088	7.51	-3.90		-3.90
4	62040	2667008	9.30	4.81		4.81
1981:1	54402	2663760	8.17	6.65		6.65
2	49901	2671361	7.47	-6.58		-6.58
3	49870	2680641	7.44	-0.92		-0.92
4	63998	2691598	9.51	2.21		2.21
1982:1	59168	2707656	8.74	7.00		7.00
2	50909	2720610	7.48	0.17		0.17
3	46018	2733879	6.73	-9.52		-9.52
4	55943	2747462	8.14	-14.36		-14.36
1983:1	53052	2756064	7.70	-11.91		-11.91
2	50040	2772394	7.22	-3.54		-3.54
3	46907	2791162	6.72	-0.16		-0.16
4	58681	2812368	8.35	2.47		2.47
1984:1	58623	2840931	8.25	7.20		7.20
2	51497	2865072	7.19	-0.42		-0.42
3	50249	2889698	6.96	3.47		3.47
4	59452	2914810	8.16	-2.25		-2.25
1985:1	59364	2938302	8.08	-2.09		-2.09
2	54759	2965230	7.39	2.74		2.74
3	53102	2993493	7.10	2.01		2.01
4	64516	3023091	8.54	4.63		4.63
1986:1	57038	3054058	7.47	-7.56	1.2	-6.36
2	58072	3086326	7.53	1.89	1.2	3.09
3	56825	3119929	7.29	2.67	1.2	3.87
4	59820	3154867	7.58	-11.15	1.2	-9.95

Collision Coverage

	Claim Counts	Exposures	4 x C/E Frequency	Annual Frequency Change	Brakelight Effect	Adjusted Frequency Change
1977:1						
2						
3						
4						
1978:1						
2						
3						
4						
1979:1	31752	1,391,649	9.13			
2	26431	1,407,146	7.51			
3	25893	1,421,620	7.29			
4	32639	1,435,072	9.10			
1980:1	31559	1,447,479	8.72	-4.44		-4.44
2	28661	1,458,885	7.86	4.59		4.59
3	27262	1,469,269	7.42	1.87		1.87
4	38529	1,478,631	10.42	14.57		14.57
1981:1	37877	1,482,731	10.22	17.17		17.17
2	30439	1,491,735	8.16	3.86		3.86
3	30699	1,501,409	8.18	10.20		10.20
4	43452	1,511,753	11.50	10.31		10.31
1982:1	41849	1,522,401	11.00	7.61		7.61
2	32909	1,534,238	8.58	5.12		5.12
3	29028	1,546,899	7.51	-8.22		-8.22
4	39665	1,560,382	10.17	-11.56		-11.56
1983:1	39579	1,569,184	10.09	-8.24		-8.24
2	33739	1,586,518	8.51	-0.86		-0.86
3	32518	1,606,892	8.09	7.84		7.84
4	44849	1,630,306	11.00	8.22		8.22
1984:1	47794	1,662,792	11.50	13.96		13.96
2	36802	1,689,934	8.71	2.40		2.40
3	36661	1,717,738	8.54	5.47		5.47
4	47389	1,746,204	10.86	-1.35		-1.35
1985:1	51129	1,778,927	11.50	-0.01		-0.01
2	43886	1,807,299	9.71	11.51		11.51
3	45121	1,834,898	9.84	15.22		15.22
4	59605	1,861,725	12.81	17.97		17.97
1986:1	55596	1,887,752	11.78	2.47	0.8	3.27
2	53113	1,913,034	11.11	14.34	0.8	15.14
3	53674	1,937,544	11.08	12.65	0.8	13.45
4	62838	1,961,281	12.82	0.07	0.8	0.87

BI CLAIM FREQUENCY REGRESSIONS

Dependent Variable: % Change in BI Claim Frequency (Q(i) - Q(i-4))

Independent Variable	Estimated Coefficient/("t"-statistic) Structural	Mixed	Trend
% Change in Gas Price (Q(i) - Q(i-4))	-.0219 (-0.18)	-0.151 (-1.23)	-
% Change in Gas Price, Lag 1 (Q(i-1) - Q(i-5))	-0.136 (-0.65)	0.123 (0.60)	-
% Change in Gas Price, Lag 2 (Q(i-2) - Q(i-6))	0.0650 (0.44)	-0.197 (-1.31)	-
% Change in Unemployment, Lag 1 (Q(i-1) - Q(i-5))	-0.149 (-1.96)	-0.148 (-2.10)	-
% Change in Unemployment, Lag 2 (Q(i-2) - Q(i-6))	.00085 (.01)	0.0359 (0.40)	-
% Change in Unemployment, Lag 3 (Q(i-3) - Q(i-7))	0.0297 (0.45)	-0.107 (-1.52)	-
% Change in Exposures/Work Age Pop. (Q(i) - Q(i-4))	0.959 (2.35)	-1.22 (-1.39)	-
Intercept	-	6.45 (2.83)	2.476 (1.78)
% Change in BI Claims, Lag 1 (Q(i-1) - Q(i-5))	-	-0.0137 (-0.073)	0.166 (0.91)
% Change in BI Claims, Lag 2 (Q(i-2) - Q(i-6))	-	-0.368 (-2.02)	0.0109 (0.058)
% Change in BI Claims, Lag 3 (Q(i-3) - Q(1-7))	-	0.231 (1.37)	0.163 (0.87)
% Change in BI Claims, Lag 4 (Q(i-4) - Q(i-8))	-	-0.269 (-1.56)	-0.183 (-1.01)
Number of Observations	32	32	32
R-squared	0.372	0.603	0.077
Standard Error of Regression	4.557	3.950	5.181
Mean of Dependent Variable	3.138	3.138	3.138

PDL CLAIM FREQUENCY REGRESSIONS

Dependent Variable: % Change in PDL Claim Frequency (Q(i) - Q(i-4))

Independent Variable	Estimated Coefficient/("t"-statistic) Structural	Mixed	Trend
% Change in Gas Price (Q(i) - Q(i-4))	-0.354 (-2.27)	-0.544 (-3.02)	-
% Change in Gas Price, Lag 1 (Q(i-1) - Q(i-5))	0.112 (0.47)	0.302 (1.24)	-
% Change in Gas Price, Lag 2 (Q(i-2) - Q(i-6))	0.0777 (0.48)	-0.133 (-0.76)	-
% Change in Unemployment, Lag 1 (Q(i-1) - Q(i-5))	0.0116 (0.13)	0.0972 (0.97)	-
% Change in Unemployment, Lag 2 (Q(i-2) - Q(i-6))	-0.0652 (-0.65)	-0.102 (-0.93)	-
% Change in Unemployment, Lag 3 (Q(i-3) - Q(i-7))	-0.186 (-2.30)	-0.308 (-3.09)	-
% Change in Exposures/Work Age Pop. (Q(i) - Q(i-4))	-2.11 (-3.81)	-3.92 (-3.22)	-
Intercept	-	2.43 (1.13)	-1.202 (-0.99)
% Change in PDL Claims, Lag 1 (Q(i-1) - Q(i-5))	-	-0.0850 (-0.36)	0.416 (1.90)
% Change in PDL Claims, Lag 2 (Q(i-2) - Q(i-6))	-	-0.284 (-1.33)	-0.0884 (-0.37)
% Change in PDL Claims, Lag 3 (Q(i-3) - Q(1-7))	-	0.126 (0.66)	-0.176 (-0.81)
% Change in PDL Claims, Lag 4 (Q(i-4) - Q(i-8))	-	-0.364 (-1.83)	-0.0455 (-0.24)
Number of Observations	28	28	28
R-squared	0.513	0.663	0.204
Standard Error of Regression	4.890	4.608	5.908
Mean of Dependent Variable	-1.290	-1.290	-1.290

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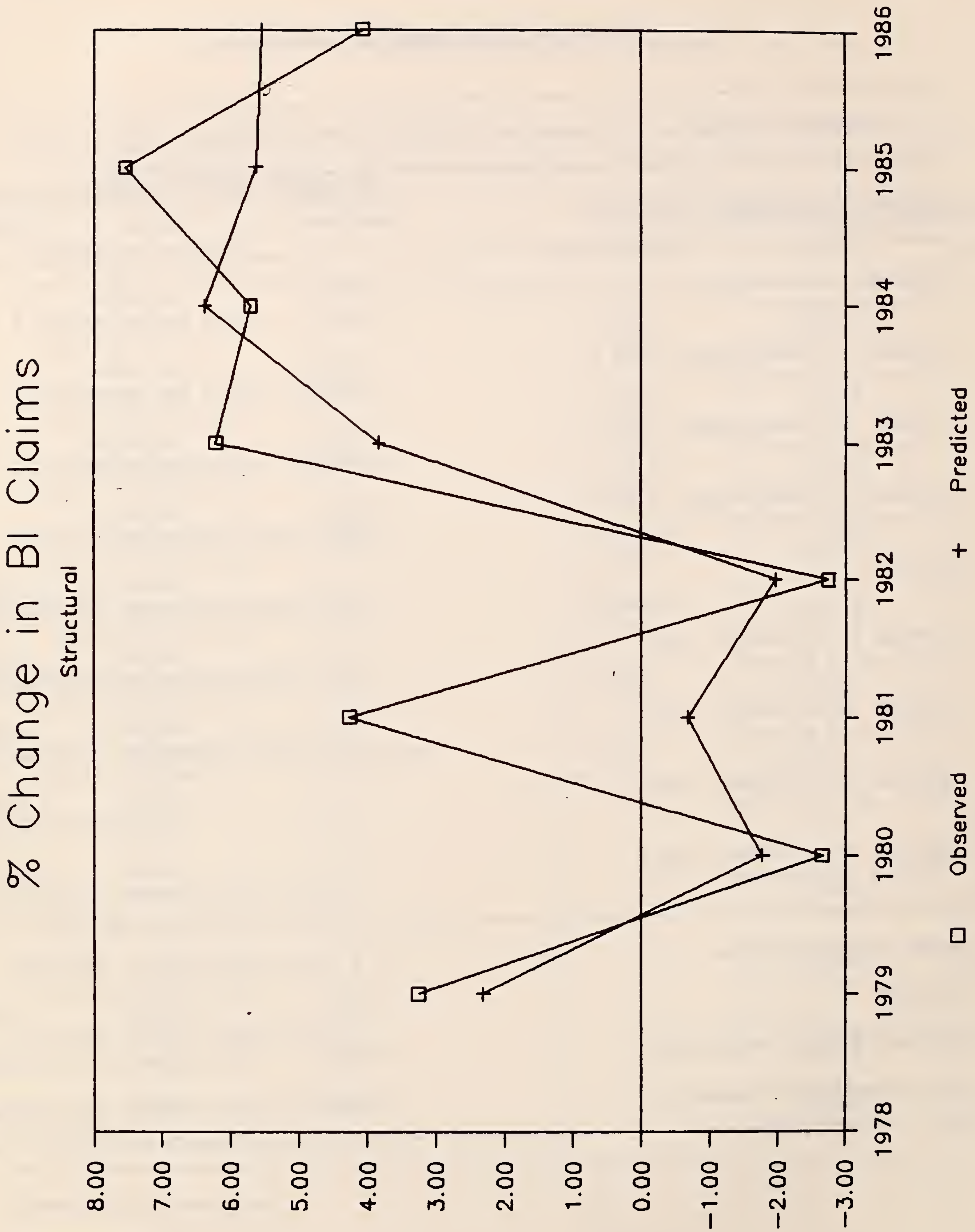
Exhibit 100D-8

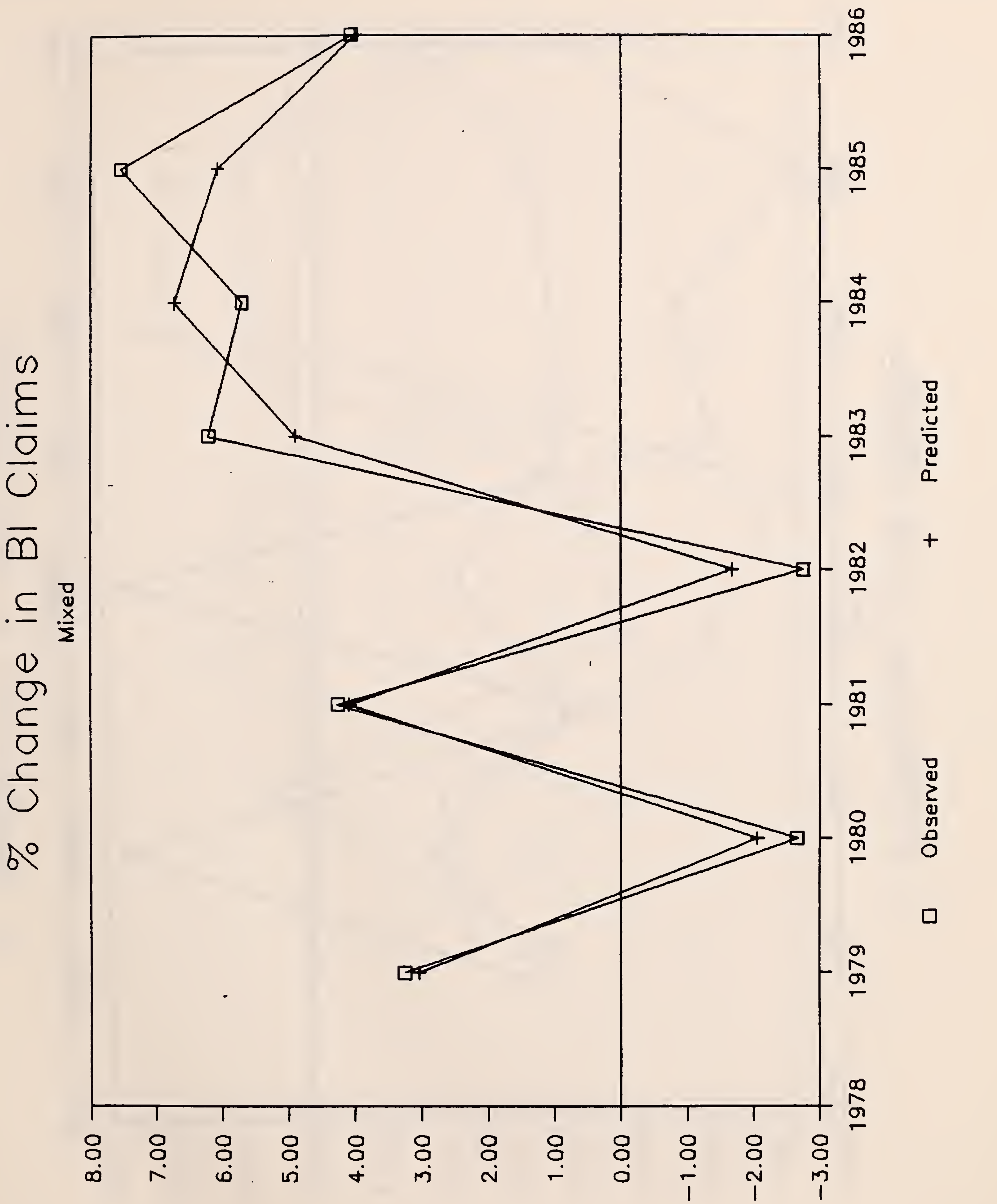
COLLISION CLAIM FREQUENCY REGRESSIONS

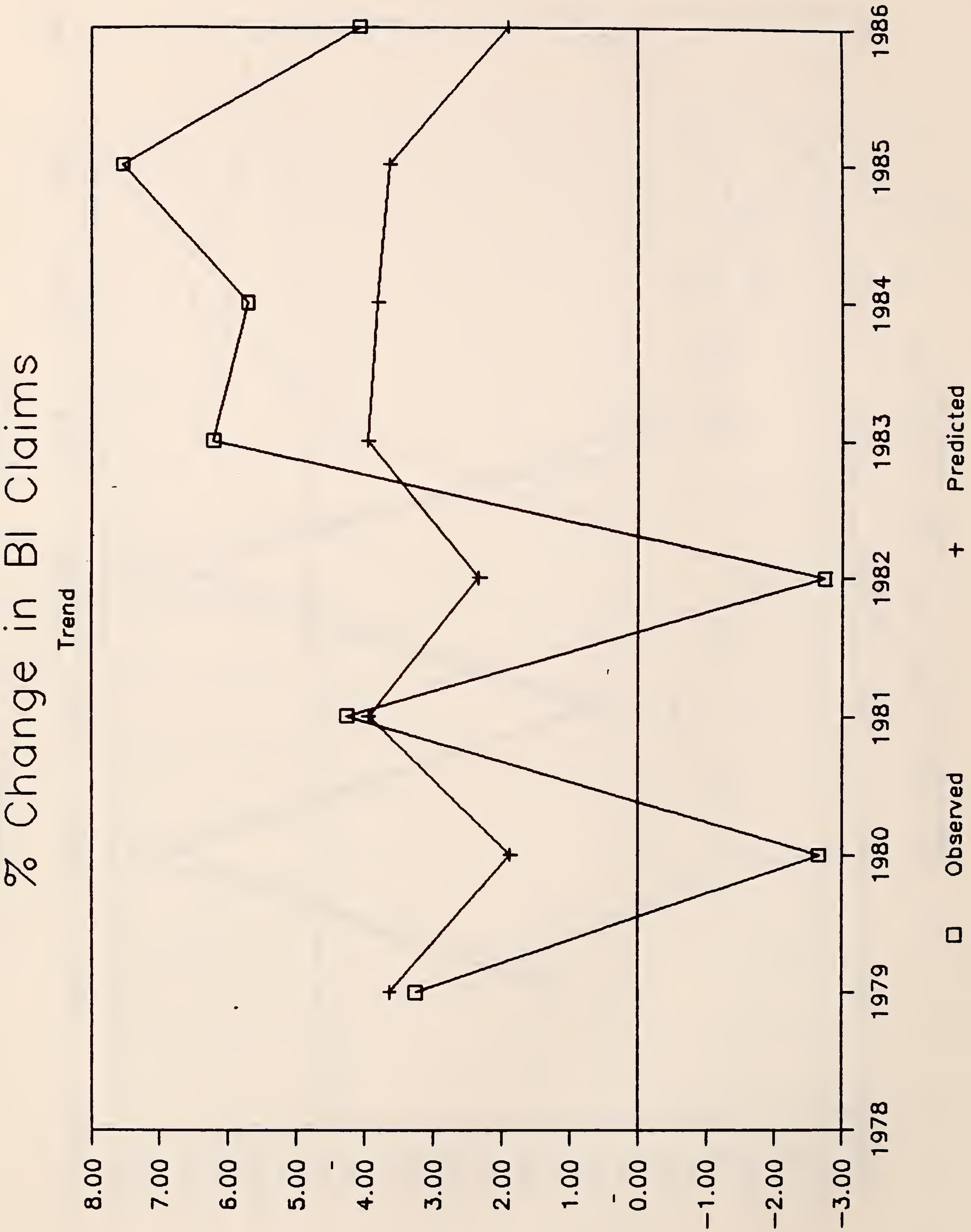
Dependent Variable: % Change in Collision Claim Frequency (Q(i) - Q(i-4))

Independent Variable	Estimated Coefficient/("t"-statistic) Structural	Mixed	Trend
% Change in Gas Price (Q(i) - Q(i-4))	-0.241 (-1.61)	-0.0335 (-0.17)	-
% Change in Unemployment, Lag 1 (Q(i-1) - Q(i-5))	0.0741 (0.51)	0.0528 (0.31)	-
% Change in Unemployment, Lag 2 (Q(i-2) - Q(i-6))	-0.126 (-0.66)	-0.00027 (-0.0014)	-
% Change in Unemployment, Lag 3 (Q(i-3) - Q(i-7))	-0.171 (-1.18)	-0.190 (-1.25)	-
Intercept	-	5.113 (1.80)	4.039 (1.85)
% Change in CL Claims, Lag 1 (Q(i-1) - Q(i-5))	-	0.336 (1.14)	0.519 (2.33)
% Change in CL Claims, Lag 2 (Q(i-2) - Q(i-6))	-	-0.164 (-0.57)	-0.0592 (-0.24)
% Change in CL Claims, Lag 3 (Q(i-3) - Q(1-7))	-	0.133 (0.52)	0.0457 (0.18)
% Change in CL Claims, Lag 4 (Q(i-4) - Q(i-8))	-	-0.337 (-1.18)	-0.271 (-1.21)
Number of Observations	24	24	24
R-squared	0.207	0.488	0.352
Standard Error of Regression	8.805	7.241	7.237
Mean of Dependent Variable	5.806	5.806	5.806

1988-AG
Exhibit 100D-9




% Change in BI Claims
Mixed
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
Observed
Predicted


% Change in BI Claims
Trend
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
−1.00
−2.00
−3.00
1978
1979
1980
1981
1982
1983
1984
1985
1986
Observed
Predicted

% Change in PDL Claims

Structural

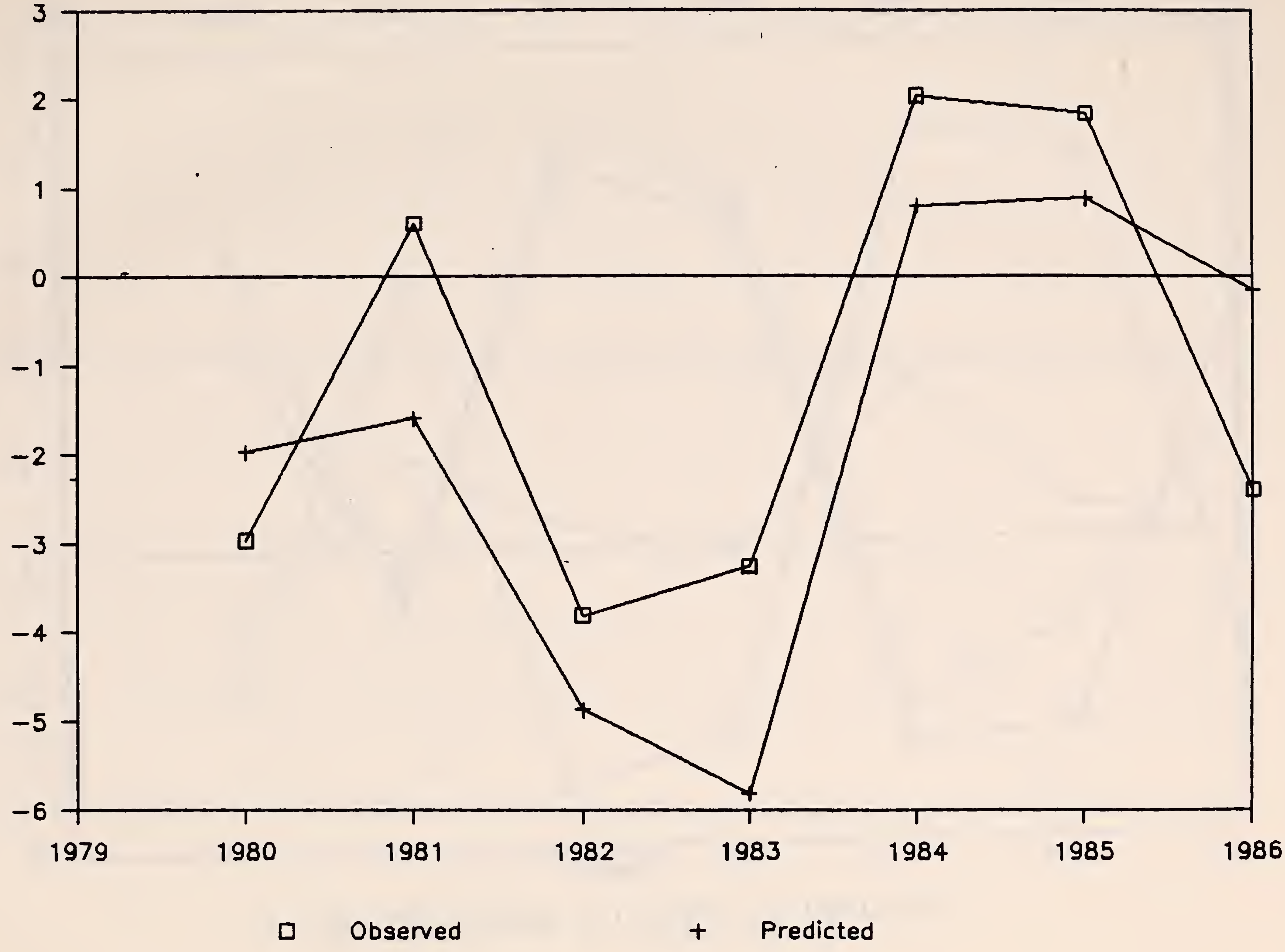


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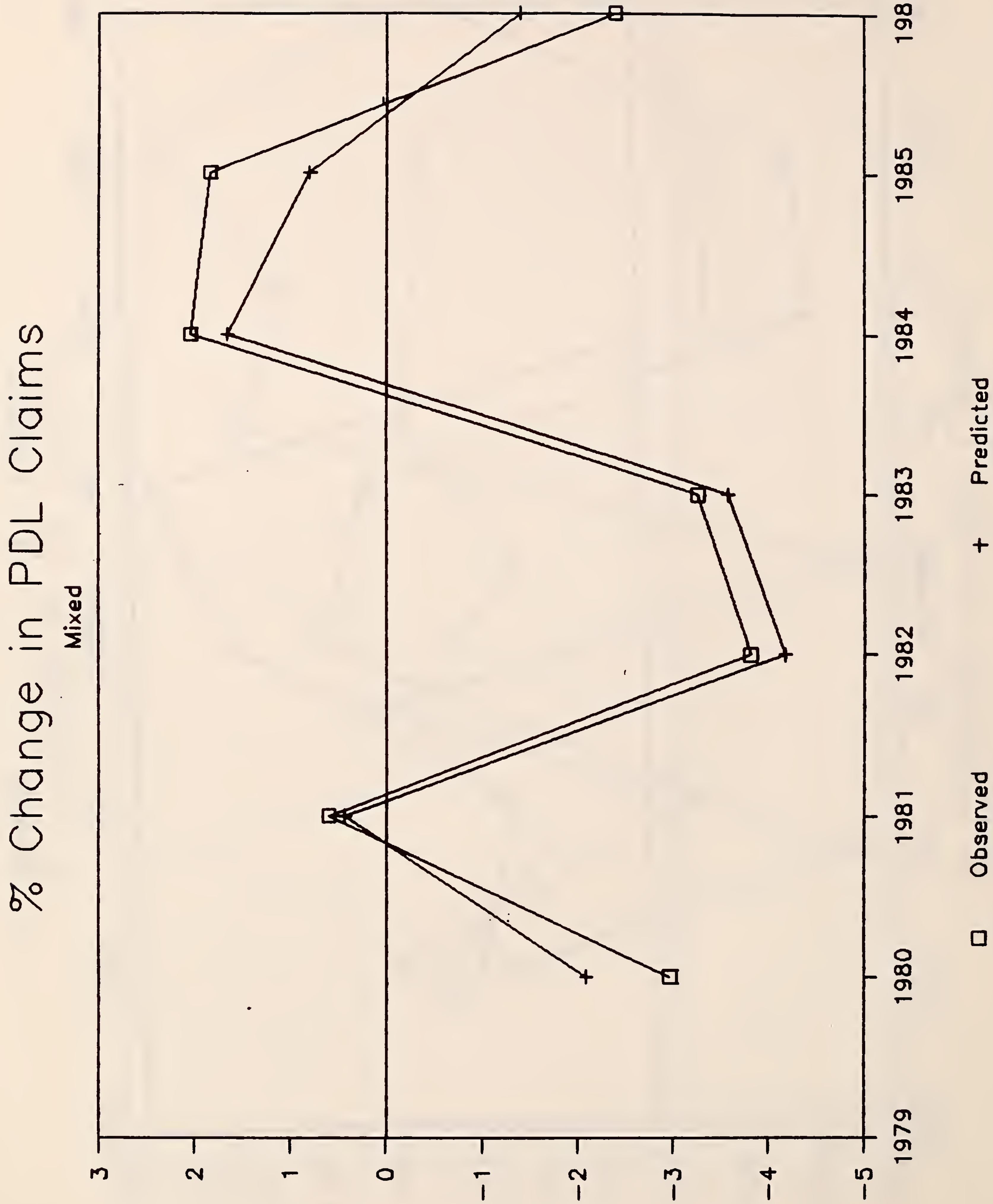
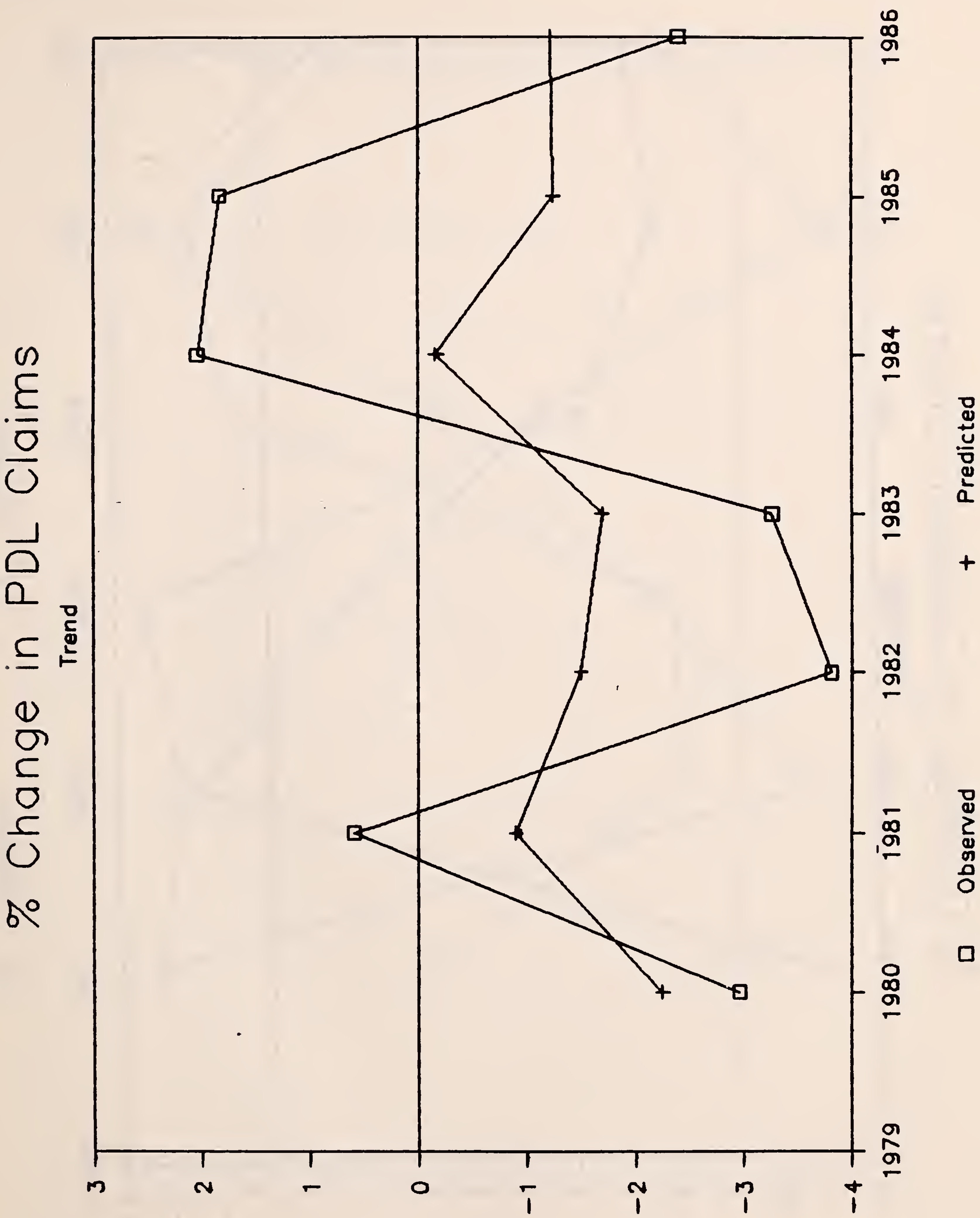
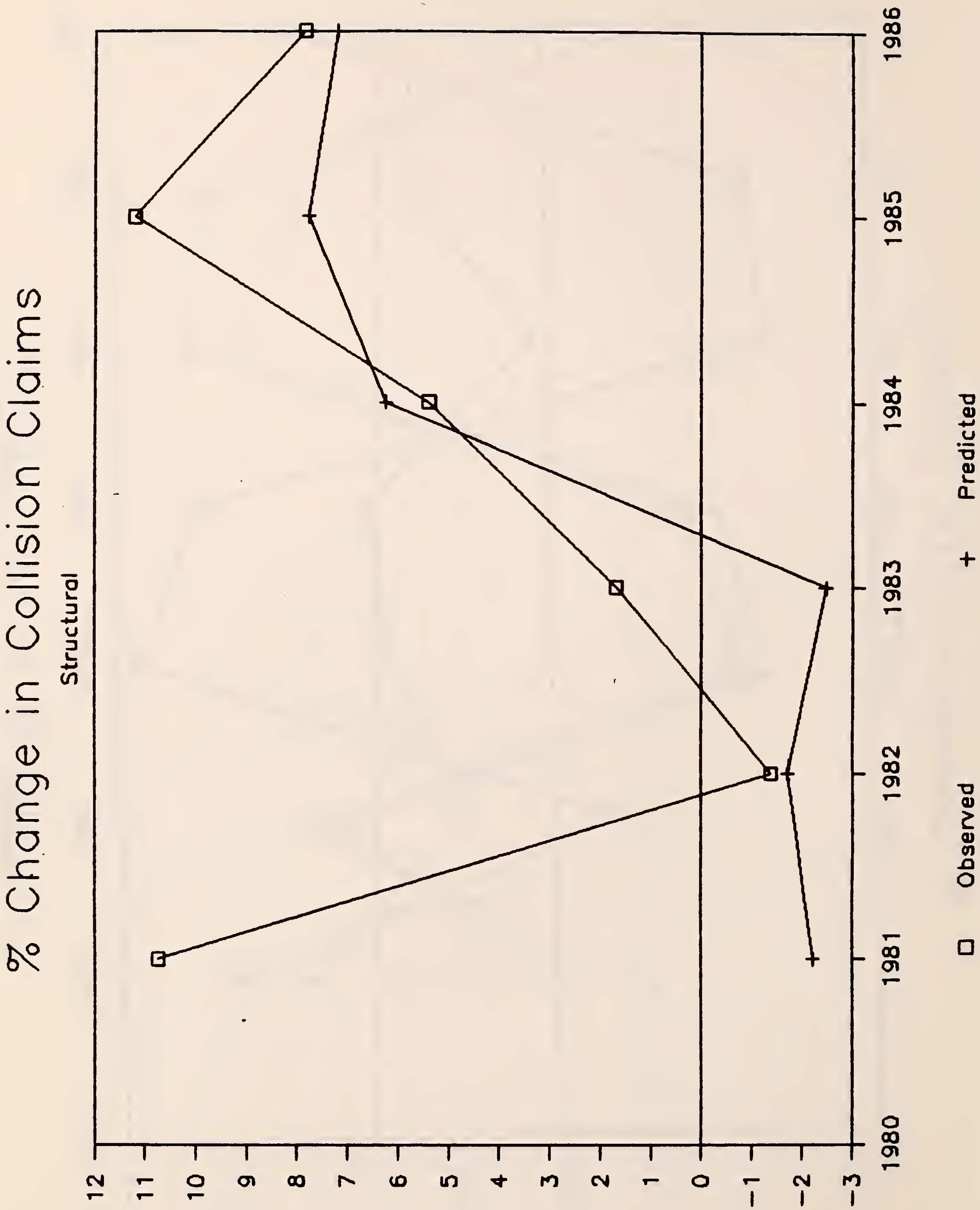
Exhibit 100D-13

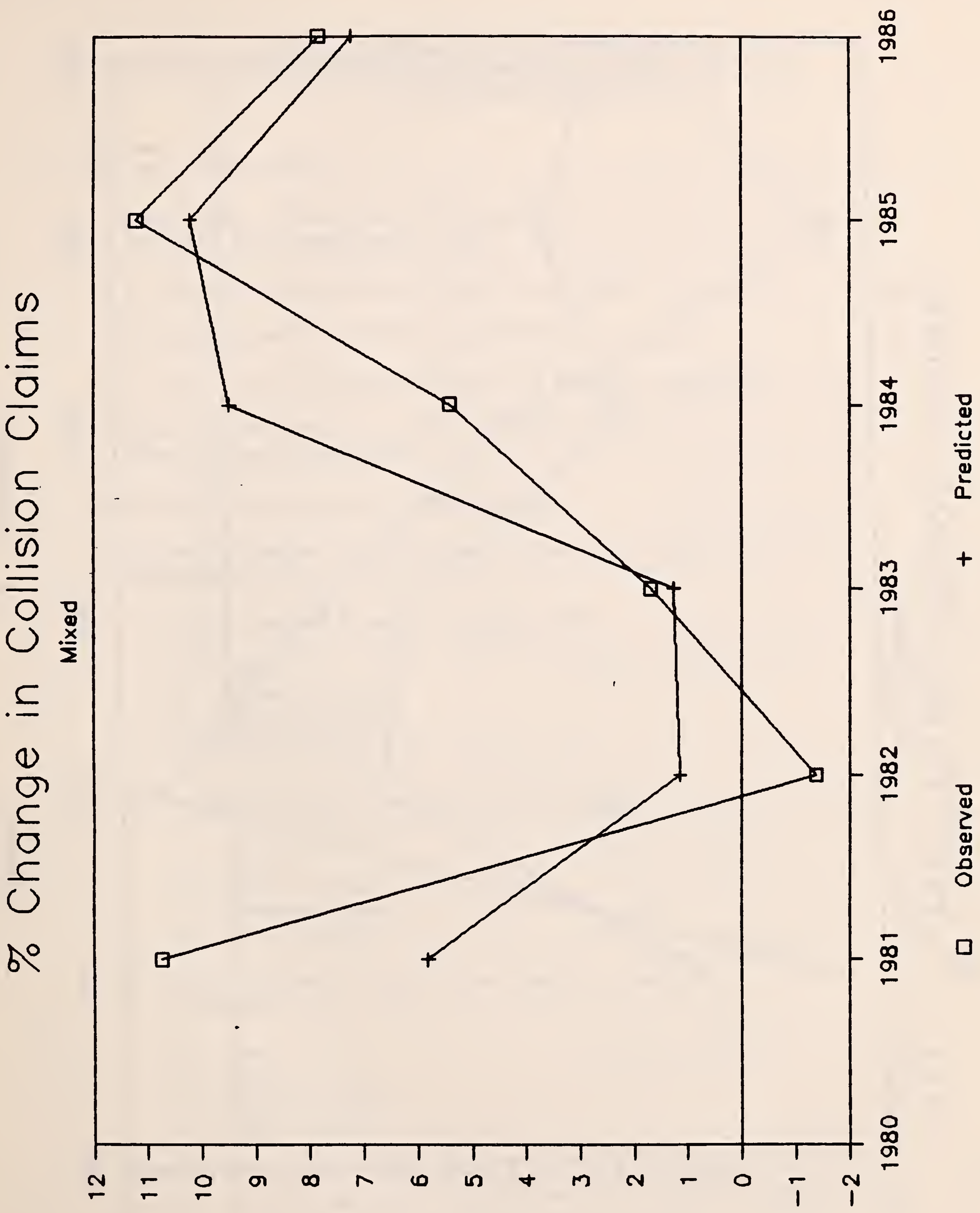


1988-AG
Exhibit 100D-14

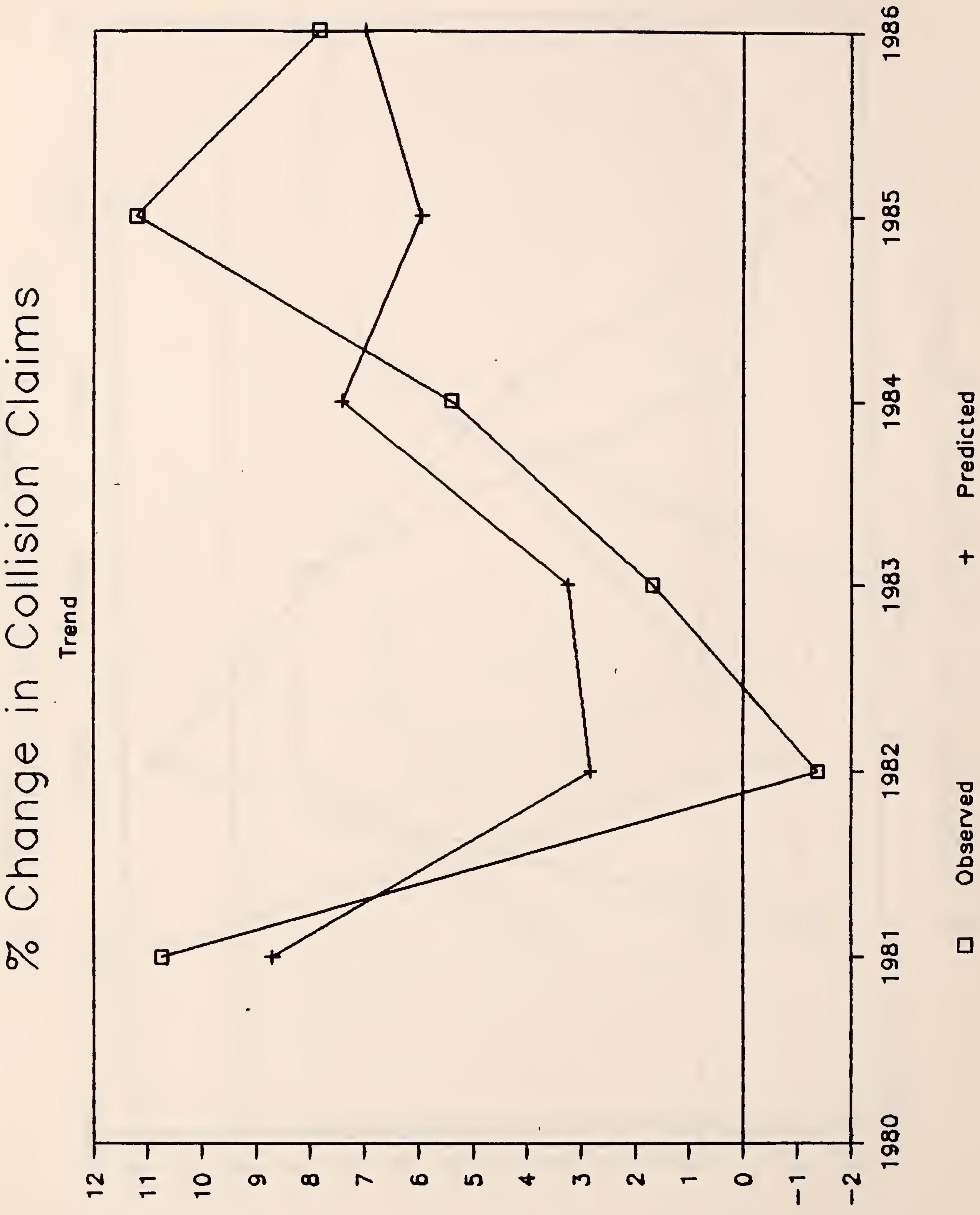



% Change in Collision Claims
Structural
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
1980
1981
1982
1983
1984
1985
1986
Observed
Predicted

1988-AG
Exhibit 100D-16



1988-AG
Exhibit 100D-17



1988-AG
Exhibit 100D-18

REPEAL OF THE SEAT BELT LAW
RECOGNITION OF THE EFFECT ON POLICY YEAR 1988
(Dry Road Conditions)

I. Seat Belt Usage Rates

A. Usage Rates Underlying 1986 Experience (for dry road conditions) ("B") — 34.0%

1. Post-law/Pre-repeal (1-1-86 to 12-3-86) — 35.0%

2. Post-repeal (12-4-86 to 12-31-86) — 24.0%

3. A = [(A1 * 337 days) + (A2 * 28 days)] / 365 days

B. Expected Usage Rates for Policy Year 1988 ("A") (for dry road conditions) — 24.0%

II. Pricing Model for Seat Belt Usage Effects

A. Projected Change in Injury Loss Costs for Vehicle Occupancts Only — 3.1%

1. Effectiveness Rates - Utilized ("E")

a.	Fatal	20.0%
b.	Severe Injury	35.0%
c.	Moderate Injury	35.0%
d.	Minor Injury	5.0%

2. Projected Change in Injuries = $\frac{(B - A)E}{1 - BE}$

a.	Fatal	2.1%
b.	Severe Injury	4.0%
c.	Moderate Injury	4.0%
d.	Minor Injury	0.5%

3. Distribution of Injury Loss Costs for Vehicle Occupants Only

a.	Fatal	4.9%
b.	Severe Injury	33.0%
c.	Moderate Injury	39.7%
d.	Minor Injury	22.4%

B. Proportion of Injury Loss Costs Due to Non-occupants — 10.0%

III. Average Expected Increase in Injury Loss Costs (for accidents occurring under dry pavement conditions) = IIA * (1-IIB) — 2.8%

REPEAL OF THE SEAT BELT LAW
RECOGNITION OF THE EFFECT ON POLICY YEAR 1988
(Wet Road Conditions)

I. Seat Belt Usage Rates

A. Usage Rates Underlying 1986 Experience (for wet road conditions) ("B") — 46.0%

1. Post-law/Pre-repeal (1-1-86 to 12-3-86) — 46.0%

2. Post-repeal (12-4-86 to 12-31-86) — 49.0%

B. Expected Usage Rates for Policy Year 1988 ("A") (for wet road conditions) — 46.0%

II. Pricing Model for Seat Belt Usage Effects

A. Projected Change in Injury Loss Costs for Vehicle Occupancts Only — 0.0%

1. Effectiveness Rates - Utilized ("E")

a. Fatal	20.0%
b. Severe Injury	35.0%
c. Moderate Injury	35.0%
d. Minor Injury	5.0%

2. Projected Change in Injuries = $\frac{(B - A)E}{1 - BE}$

a. Fatal	0.0%
b. Severe Injury	0.0%
c. Moderate Injury	0.0%
d. Minor Injury	0.0%

3. Distribution of Injury Loss Costs for Vehicle Occupants Only

a. Fatal	4.9%
b. Sévere Injury	33.0%
c. Moderate Injury	39.7%
d. Minor Injury	22.4%

B. Proportion of Injury Loss Costs Due to Non-occupants — 10.0%

III. Average Expected Increase in Injury Loss Costs (for accidents occurring under wet pavement conditions) = IIA * (1-IIB) — 0.0%

DISTRIBUTION OF BODILY INJURY ACCIDENTS
BY ROAD SURFACE CONDITIONS (Accident Year 1980)[1]

Road Conditions	Fatal	Non-Fatal	Total
Dry	672	36,509	37,181
Total Wet	140	11,900	12,040
(Wet)	(105)	(9,259)	
(Icy)	(18)	(1,330)	
(Snowy)	(17)	(1,121)	
(Other)		(190)	
TOTAL			49,221

Proportion Dry = 37,181 / 49,221 = .755

Proportion Wet = 12,040 / 49,221 = .245

[1]Source: "1980 Motor Vehicle Accident Experience," Commonwealth of Massachusetts Registry of Motor Vehicles, Statistics section.

REPEAL OF THE SEAT BELT LAW
RECOGNITION OF THE EFFECT ON POLICY YEAR 1988

1.	Expected injury loss costs increase for accidents occurring under dry pavement conditions (from Exhibit 6)	2.8%
2.	Proportion of accidents occurring under dry pavement conditions (from Exhibit 8)	.755
3.	Expected Injury loss cost increase for accidents occurring under wet pavement conditions (from Exhibit 7)	0.0%
4.	Proportion of accidents occurring under wet pavement conditions (from Exhibit 8)	.245
5.	Average expected injury loss cost increase	2.1%

(5) = [(1) * (2)] + [(3) * (4)]

Analysis of the Impact of High-Mounted Center Brake Lights: Accident Year 1986/Policy Year 1988

Property Damage Liability and Collision Coverages

		Accident Year 1986		Policy Year 1988	
1.	Percentage reduction in incidence of relevant rear-end collisions when leading car has high-mounted center brake lights.		53%		53%
2.	Percentage reduction in severity of remaining relevant rear-end collisions when leading car has high-mounted center brake-lights. (PDL: damage to leading car, Col.: damage to following car)	PDL: Col:	57% 0%	PDL: Col:	57% 0%
3.	Percentage reduction in loss costs of relevant rear-end collisions when leading car has high-mounted center brake lights. (3) = (1) + [(2) * [1.00 - (1)]]	PDL: Col:	80% 53%	PDL: Col:	80% 53%
4.	Severity of rear-end collisions relative to all accidents.	PDL: Col:	56% 57%	PDL: Col:	56% 57%
5.	Percentage of all accidents that are relevant rear-end collisions.		28.9%		28.9%
6.	Percentage reduction in loss costs if all vehicles were equipped with high-mounted center brake lights. (6) = [(3) * (4) * (5)]	PDL: Col:	12.9% 8.7%	PDL: Col:	12.9% 8.7%
7.	Estimated percentage of private passenger cars that are model years 1986 and later. (1988 MARB Section 100CD-5, Exhibit 1, Page 3, 4)		12.3%		32.0%
8.	Relative volume of potential claims by private passenger cars that are model years 1986 and later. (1988 MARB Section 100CD-5, Exhibit 2, Page 3)		1.15		1.08
9.	Estimated percentage of total fleet that is private passenger cars.		85%		85%
10.	Estimated percentage of model year 1986 and later vehicles that are equipped with high-mounted center brake-lights.		75%		75%
11.	Estimated percentage of potential claims involving vehicles that are equipped with high-mounted center brake-lights. (11) = [(7) * (8) * (9) * (10)]		9.0%		22.0%
12.	Factor for cost to repair newer vehicle.	PDL: Col:	1.05 1.00	PDL: Col:	1.05 1.00
13.	Estimated overall savings from high-mounted center brake lights. (13) = [(6) * (11) * (12)]	PDL: Col:	1.2% 0.8%	PDL: Col:	3.0% 1.9%
14.	Change in savings from 1986 to 1988.			PDL: Col:	1.8% 1.1%

Analysis of the Impact of High-Mounted Center Brake Lights: Accident Year 1985/Accident Year 1986

Property Damage Liability and Collision Coverages

		Accident Year 1985	Accident Year 1986
1.	Percentage reduction in incidence of relevant rear-end collisions when leading car has high-mounted center brake lights.	53%	53%
2.	Percentage reduction in severity of remaining relevant rear-end collisions when leading car has high-mounted center brake-lights. (PDL: damage to leading car, Col.: damage to following car)	PDL: 57% Col: 0%	PDL 57% Col: 0%
3.	Percentage reduction in loss costs of relevant rear-end collisions when leading car has high-mounted center brake lights. (3) = (1) + [(2) * [1.00 - (1)]]	PDL: 80% Col: 53%	PDL: 80% Col: 53%
4	Severity of rear end collisions relative to all accidents.	PDL: 56% Col: 57%	PDL: 56% Col: 57%
5.	Percentage of all accidents that are relevant rear-end collisions.	28.9%	28.9%
6.	Percentage reduction in loss costs if all vehicles were equipped with high-mounted center brake lights. (6) = [(3) * (4) * (5)]	PDL: 12.9% Col: 8.7%	PDL: 12.9% Col: 8.7%
7.	Estimated percentage of private passenger cars that are model years 1986 and later.	0.4%	12.3%
8.	Relative volume of potential claims by private passenger cars that are model years 1986 and later.	1.15	1.15
9.	Estimated percentage of total fleet that is private passenger cars.	85%	85%
10.	Estimated percentage of model year 1986 and later vehicles that are equipped with high-mounted center brake lights.	75%	75%
11.	Estimated percentage of potential claims involving vehicles that are equipped with high-mounted center brake-lights. (11) = [(7) * (8) * (9) * (10)]	0.3%	9.0%
12.	Factor for cost to repair newer vehicle.	PDL: 1.05 Col: 1.00	PDL 1.05 Col: 1.00
13.	Estimated overall savings from high-mounted center brake lights. (13) = [(6) * (11) * (12)]	PDL: 0.0% Col: 0.0%	PDL: 1.2% Col: 0.8%
14.	Change in savings from 1985 to 1986.		PDL: 1.2% Col: 0.8%

Analysis of the Impact of High-Mounted Center Brake Lights: Accident Year 1986/Policy Year 1988

Bodily Injury Liability Coverage

		Accident Year 1986	Policy Year 1988
1.	Percent of Bodily Injury accidents that are rear-end collisions.	17.6%	17.6%
2.	Percent of rear-end collisions that are relevant.	83%	83%
3.	Percentage reduction in incidence of relevant rear-end collisions when leading car has high-mounted center brake lights.	22%	22%
4.	Percentage reduction in severity of remaining relevant rear-end collisions when leading car has high-mounted center brake-lights. (From Exhibit 100D-22, Page 1)	57%	57%
5.	Percentage reduction in loss costs of relevant rear-end collisions when leading car has high-mounted center brake lights. (5) = [(3) + [(4) * [1.00 - (3)]]] * (1) * (2)	9.6%	9.6%
6.	Estimated percentage of potential claims involving vehicles that are equipped with high-mounted center brake-lights. (From Exhibit 100D-22, Page 1)	9.0%	22.0%
7.	Estimated savings from high-mounted center brake lights. (7) = [(5) * (6)]	0.9%	2.1%
8.	Change in savings from 1986 to 1988.		1.2%

1988-AG
Exhibit 100D-24

MONTHLY CAR FIRES: CITY OF CAMBRIDGE

Pre-Investigation:

1982	June	43
	July	40
	August	38
	September	41
	October	40
	November	37
	December	40
	AVERAGE:	39.9/Month

Post-Investigation:

1983	January	11
	February	5
	March	6
	April	6
	May	20
	June	19
	July	16
	August	10
	September	6
	October	7
	November	5
	December	5
	AVERAGE:	9.7/Month

Source: City of Cambridge

DOT HS- 805 360

VALIDATION OF THE REDUCTION OF REAR-END COLLISIONS BY A HIGH-MOUNTED AUXILIARY STOPLAMP

Raymond E. Reilly, Ph.D.
David S. Kurke
C.C. Buckenmaier, Jr.

Allen Corporation of America
401 Wythe Street
Alexandria, Virginia 22314

Contract No. DOT HS-7-01756
Contract Amt. $267,968

MAY 1980
FINAL REPORT

Prepared For
U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Washington, D.C. 20590

Technical Report Documentation Page

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16. Abstract

This study was a field validation of the effectiveness of an auxiliary high-mounted stoplamp in reducing rear-end collisions. A previous study (DOT-HS-803-467), using taxicabs, found a 54 percent reduction in relevant rear-end impacts to vehicles equipped with the auxiliary stoplamp.

The present study used 5,400 telephone company passenger vehicles, half test, half control, which accumulated 55 million miles during a 12-month continuous data collection period. The results showed a statistically significant 53 percent reduction in relevant rear-end impact rate in the test group as compared to the control group. The findings were thus consistent with the previous study on taxicabs.

17. Key Words	18. Distribution Statement
1. Vehicle lighting and signaling 2. Rear-end collisions 3. Accident prevention	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

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Unclassified	Unclassified	50	

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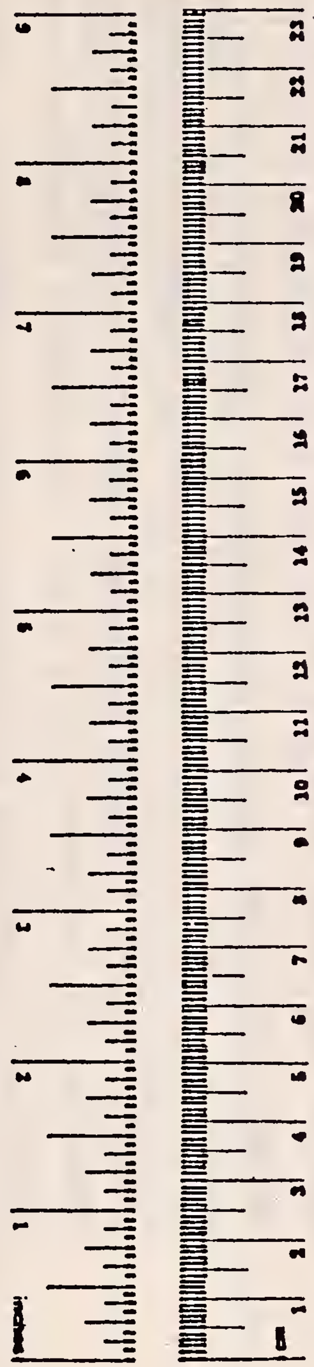
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

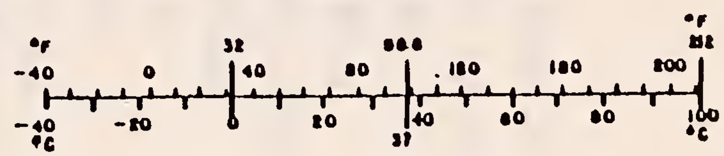
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



Summary

Purpose

The object of the present study was to evaluate the effect of a single high-mounted auxiliary stoplamp on rear-end collisions. The study was a comprehensive field validation of the results of a previous investigation (DOT-HS-5-01228) (Reference 7) which used taxicabs operating in the Washington, D.C. metropolitan area. That study reported a 54 percent reduction in rear-end impacts to taxicabs equipped with the auxiliary stoplamp.

Background

The relative effectiveness of vehicle rear-lighting and signaling systems had never been empirically evaluated in a controlled field study using a large and varied population of vehicles and drivers. The results of the preceding study, if valid, would represent a landmark improvement in vehicle rear lighting and signaling, and a correspondingly significant reduction in rear-end collisions. The present study was conducted to validate the previous findings by using passenger cars other than taxicabs and operating in cities other than Washington, D.C.

Method

Accident and exposure (mileage) data were collected on a total of roughly 5,400 telephone company passenger cars, about 2,500 of which were equipped with the auxiliary stoplamp in question. The lamp was a Stimsonite Model 3050 Hi-Lite manufactured by Amerace Brands Corporation of Butler, New Jersey. For this study, as in the previous study, the lamp was equipped with a General Electric #1142 bulb. The remaining cars served as controls. The vehicles were operated by seven companies of the Bell Telephone System, with vehicle locations ranging from New England to Florida, and in Illinois and California. Data were collected from 1 January 1979 through 31 December 1979 during which period the vehicles ran a total of approximately 55 million miles.

Results

The test group received 53 percent fewer rear-end impacts than did the control group. The difference was statistically significant beyond the .01 level of confidence. The result is in agreement with the preceding study which found a 54 percent reduction in rear-end impacts. Both studies are with reference to "relevant" rear-end accidents (where rear lighting would be a factor, as opposed to any and all rear-end collisions).

The effect of the auxiliary lamp may be due to several factors, either separately or in combination. One explanation of the beneficial effect of the auxiliary stoplamp is that it is centrally located in, and at the approximate eye level of, a following driver's forward field of view. Thus, it is not only generally more visible to the following driver but it is near the line of sight used to view traffic ahead by looking through the backlight and windshield of a lead vehicle.

Second, the auxiliary stoplamp is an unambiguous brake signal, since it serves that function alone, whereas standard equipment lamps serve either as brake (stop) and presence indicators or as brake, presence, and turn indicators.

A third possibility is that the auxiliary stoplamp alters the vehicle's rear lighting visual geometry, for example, by forming a triangular array with the standard brakelamps and that this somehow may improve a following driver's detection speed, frequency and distance with respect to the lead vehicle.

A fourth explanation is that the effect is due to the novelty of the auxiliary stoplamp. For reasons stated in the Discussion section of this report the authors believe, however, that novelty contributed little to the beneficial effect of the auxiliary lamp.

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Validation of the Reduction in Rear-end Collisions Using a High-Mounted Auxiliary Stoplamp

Introduction

In recent years the effectiveness of vehicle rear lighting and signaling systems has been the subject of much research (e.g., 1, 2, 3, 4, 5, 6, 7)*. Studies have been done in the context of laboratory simulations, controlled driving, and field evaluations. Signal characteristics have been examined ranging from a single high-mounted auxiliary stoplamp actuated by depression of the vehicle's brake pedal to elaborate systems involving single or multiple lamps with vehicle deceleration coded by lamp flash rate, lamp intensity, or both. In a recent study (2) no less than forty-one deceleration displays were investigated to determine a subject's ability to discriminate the signal parameters (combinations of flash rate and lamp intensity). In general, laboratory and simulation studies have been inconclusive.

In 1978 a field study (8) was conducted using fleets of taxicabs to evaluate the possible effect of three different rear lighting configurations on rear impacts to the cabs. A fourth group (standard equipment) served as the control. The three experimental groups and the control configurations are shown in Figure 1. As may be seen in the figure, Configuration No. 1 consisted of standard rear lighting plus a single, centrally located high-mounted stoplamp. Configuration No. 2 used dual high-mounted auxiliary lamps that operated as stop and turn signals in synchrony with the standard stop and turn lamps below.

Configuration No. 3 did not use auxiliary lamps. Instead, the standard lamps were rewired to separate the presence function from the stop and turn functions. Thus, the outboard lamps served as presence lamps. The inboard lamps signaled stop and turn. The control group (Configuration No. 4) consisted of standard, single compartment taillamps, which displayed presence, stop and turn functions.

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*References are listed in Appendix A.

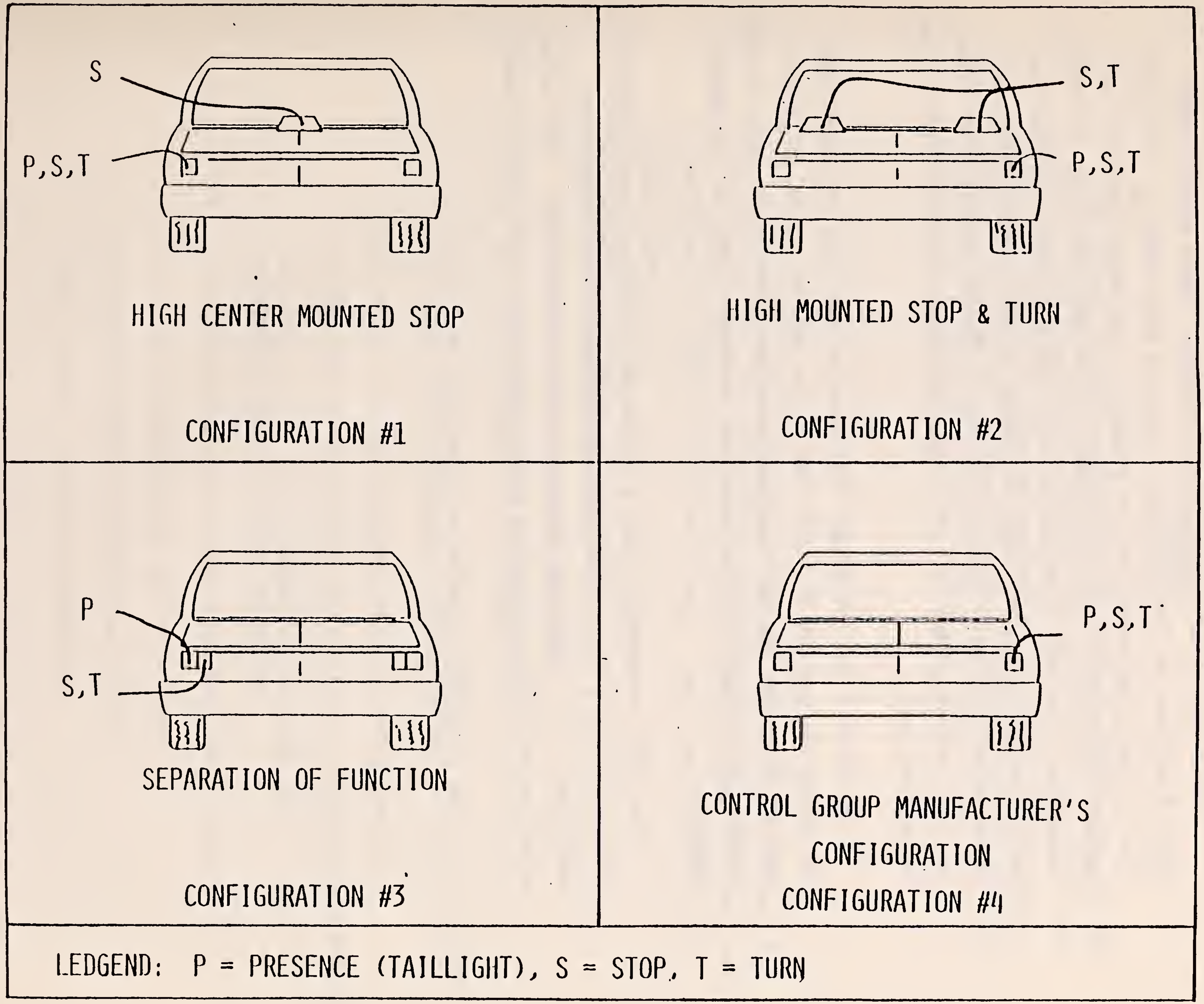

Figure 1--Lamp configurations examined in previous study (after Kohl and Baker,8)

The control group consisted of standard, single cavity lamps which functioned as the presence, stop, and turn signals. All vehicles in that study were Chrysler products. The study reported a 54 percent reduction in rear-end impacts to the cabs that were of Configuration No. 1 (single high-mounted auxiliary stoplamp) in comparison to the control group, for those accidents in which rear lighting was judged to be a factor. Relevant rear-end accident rates for the other two configurations (Nos. 2 and 3) were not significantly different from the control group.

The results for the single high-mounted lamp also indicated that the effect was greater at night than in the daytime. And, accidents that did occur for the test vehicles (Configuration No. 1) were, on the average, associated with the lower cost to repair than for the control vehicles.

The study recommended that a follow-on validation investigation be conducted using a fleet other than taxicabs and a city other than Washington, D.C., which was the site of the taxicab study. That recommendation led to the validation effort described in the present report.

Figure 1--Lamp configurations examined in previous study (after Kohl and Baker,8)

Purpose

The object of this research was to validate the findings of the study (8) described above. That is, the task was to conduct a comprehensive field evaluation of the effect of a single high-mounted auxiliary stoplamp on rear-end collisions using vehicles other than taxicabs and locations other than Washington, D.C.

Method

To achieve the needed range of driving conditions and exposure, and to obtain complete and reliable data, numerous specifications were established as a goal for the test fleet. These specifications are listed below.

Test Fleet Requirements and Selection

a. The vehicles could not be taxicabs.

b. All vehicles were to be passenger cars.

c. Sufficient accidents and mileage (exposure) data were required for statistical validation of the results.

d. All major U.S. manufacturers were to be represented.

e. A wide range of geographic distribution of vehicles was desired.

f. Vehicles were to be available for the study for at least 12 consecutive months of data collection.

g. Reliable and complete accident reporting was essential.

h. The vehicles needed to be well maintained.

i. A large population of drivers was desired.

j. Round-the-clock exposure was desired.

Based on general estimates of accident rates and average annual exposure per vehicle for various fleets it was determined that 50 million

vehicle miles would be needed. All manner of fleets were considered for the study including Hertz and Avis rental car fleets, G.S.A. vehicles, sales fleets, oil company fleets, automobile club members, utility company vehicles, and telephone company vehicles. By far, the best candidates were the fleets owned and operated by the various companies in the Bell Telephone System, of which the American Telephone and Telegraph Company (AT&T) is the parent organization. Their vehicles met all of the requirements listed above with the exception of round-the-clock exposure. The vehicles are operated mainly during business hours.

Telephone company vehicles average about 10,000 miles per year and have a lower than average accident rate. Accordingly, Allen Corporation approached AT&T and the associated telephone companies to acquire participation of 6,000 vehicles. AT&T and the companies graciously agreed to cooperate in the study in the interest of national highway safety. Table 1 shows the participating companies and the number of study vehicles provided by each.

The majority of vehicles in the study operated in and around the states and cities shown in Table 2, although some vehicles did range considerably farther afield. From the cities listed, it is apparent that the test was not restricted to urban driving in large cities.

Specifications of the Auxiliary Stoplamp

The auxiliary stoplamp was identical to that used in the preceding study (8). It was a Stimsonite Hi-Lite, Model 3050 manufactured by the Amerace Corporation of Butler, New Jersey. All lamps used in the present study were manufactured in a single production run. Each lamp had a General Electric #1142 bulb. Each bulb had a copper screen insert between the upper and lower surface of the lamp housing to dissipate heat. The screen was used in the previous study as well. The screen did not influence the luminous emittance of the lamp.

TABLE 1

PARTICIPATING COMPANIES AND NUMBER OF VEHICLES PROVIDED

Company	No. of Vehicles Provided
American Telephone and Telegraph Company (Parent Organization)	
New England Bell	564
New York Bell	730
Bell of Pennsylvania	240
Chesapeake and Potomac Telephone	1,840
Southern Bell	798
Illinois Bell	490
Pacific Telephone	732
Total	5,394

TABLE 2

PARTIAL LISTING OF STUDY CITIES

SOUTHERN BELL

Georgia

Norcross	Smyrna	Columbus
Atlanta	Savannah	
Marietta	Macon	

Florida

Miami	Coral Gables	Naranja
Hialeah	Homestead	Jacksonville
Orlando	Hollywood	Fort Lauderdale
Plantation	Pompano Beach	Margate

North Carolina

Spindale	Gastonia	Charlotte
Shelby	Raleigh	Asheville
Clyde	Greensboro	Winston Salem
Wilmington	Laurinburg	Lincolnton
Lenoir	Statesville	Chapel Hill
Goldsboro	Burlington	

South Carolina

Greenville	Charleston
Spartanburg	Columbia

PACIFIC TELEPHONE

San Diego Region

Orange	Fullerton	Santa Ana
Orea	Anaheim	San Diego
Fontana	San Clemente	Escondido
Riverside	Costa Mesa	La Mesa
Corona	Newport Beach	
Arlington	Irvine	

San Francisco Region

Oakland	Pleasanton	Salinas
San Jose	Redwood City	Castro Valley
Concord	San Francisco	Fremont
San Rafael	Hayward	San Mateo
Menlo Park	Sunnyvale	

Sacramento Region

Bakersfield	Sacramento	Chico
Stockton	Fresno	San Luis Obispo
Modesto	Santa Rosa	Merced
Visalia	Napa	Redding

Los Angeles Region

El Segundo	Compton	Pasadena
Hawthorne	Gardena	El Monte
Los Angeles	Torrance	Chatsworth
Paramount	Alhambra	Van Nuys
Canoga Park	Glendale	Ventura

ILLINOIS BELL

Chicago	Lyons	Westhaven
Chicago Heights	Summit	Calumet City
Glenwood	Chicago Ridge	Alsip
Villa Park	Oak Lawn	Cicero
Bellwood	Harvey	Schaumburg
Elk Grove	Addison	Mt.Prospect
Northbrook	Mundelin	Wheeling
Arlington Heights	Waukegan	Highland Park
Lake Villa	Barrington	Elgin
Harwood Heights	River Forest	Franklin Park
Morton Grove	Evanston	

CHESAPEAKE AND POTOMAC TELEPHONE

Virginia

Richmond
(etc.)

West Virginia

Charleston	Logan
Parkersburg	Fairmont
Clarksburg	(etc.)

Maryland

Baltimore	Annapolis
(etc.)	

Concord San Francisco San Mateo Baltimore Annapolis
San Rafael Hayward
Sunnyvale

TABLE 2

PARTIAL LISTING OF STUDY CITIES (continued)

NEW ENGLAND BELL

Rhode Island

Providence
East Providence
Lincoln
Pawtucket
Warwick

Massachusetts

Framingham
Bourne
So. Yarmouth
Cambridge
Arlington
Dedham
Back Bay
West Boylston
Springfield
Millbury
Ayer
Greenfield
Southboro
Chelmsford
Methuen
Salem
Everett
Brokton
Braintree
Bedford
Watertown
Medford
Boston
Charlestown
Pittsfield
Westfield
Holden
Northampton
Webster
Tewksbury
Haverhill
Lawrence
Lynn
Malden
Needham
Waltham
Newton
Woburn
Somerville
Dorchester
Marlboro
Great Barrington
Chicopee
Lunenburg
Holyoke
Worcester
Lowell
Danvers
Wakefield
Revere
Newburyport

Maine

Dover
Farmington
Portland
Calais
Bangor
Brunswick
Biddeford
Houlton
Waterville
Lewiston
Ellsworth
Augusta
Presque Isle

Vermont

So. Burlington
White River Junction

New Hampshire

Lebanon
Nashua
Littleton
Petersburg
Claremont
Greenland
Laconia
Keene
Somersworth
Manchester

NEW YORK BELL

Brooklyn
Bronx
Springfield Gardens
Manhattan
New York
(etc.)

BELL OF PENNSYLVANIA

Philadelphia Area
Pittsburg Area

The housing of the lamp was made of molded black plastic and was 7¼ inches wide by 1½ inches high by 3 inches deep. The color of the lens was red. The lens was 6¼ inches wide by 13/16 inches high.

The lamp was mounted at the center leading edge of the trunk lid by means of a self-adhering pad. The lamp was located just as in the previous study as depicted in Configuration No. 1 in Figure 1 as described earlier. One electrical lead of the lamp was connected to ground inside the trunk area. The other lead was connected directly to the brake light switch located on the steering column beneath the instrument panel. Thus, the lamp was illuminated only when the brake pedal was depressed. (The lamp did not flash with the turn signals or emergency flasher, nor was it illuminated as a presence lamp).

The goniometric data in Table 3 are taken from the previous study (8).

<u>Stoplamps Installed and Baseline Odometer Readings Obtained</u>

Vehicles at each telephone company garage/lot were divided randomly into two groups as equivalent as possible in make, model and year. Stationwagons and hatchbacks were excluded because they could not have the auxiliary stoplamp mounted without a special bracket. All vehicles in the study had automatic transmissions.

Stoplamps were assigned randomly such that half of each of the two equated groups had a light and thus became test vehicles. The remainder were designated as control vehicles. No modifications were made to the O.E.M.* equipment of any vehicle in the study, either test or control.

Baseline odometer readings were obtained for the study vehicles as of 1 January 1979. All lamps were installed prior to that time. All vehicles were identified by telephone company vehicle numbers which indicated the make, model and year of the vehicle. These were not manufacturer vehicle identification numbers (V.I.N.s), however. Allen Corporation provided the companies with a serialized list of study vehicle numbers.

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*Original equipment manufacturer

TABLE 3

STIMSONITE MODEL 3050 HI-LITE WITH GENERAL ELECTRIC BULB NO. 1142

Test Points		Candle Power #1142 Bulb
10°U	10°L	0
	V	6.0
	10°R	4.9
5°U	10°L	2.7
	5°L	10.4
	V	15.9
	5°R	17.0
	10°R	20.3
H	10°L	14.3
	5°L	25.2
	V	32.3
	5°R	41.7
	10°R	41.1
5°D	10°L	14.3
	5°L	29.6
	V	34.0
	5°R	47.7
	10°R	47.1
Volts		12.794
Current		1.454

After Kohl and Baker (8).

Whether a vehicle was "test" or "control," however, was not indicated on the company's list. This "omission" was necessary to establish the first phase of a "double-blind" accident classification scheme wherein neither the telephone company personnel submitting accident data nor the Allen personnel classifying the accidents knew whether a vehicle belonged to the test or control group.

Study Fleet Composition by Make, Size and Model Year

Vehicle Make

Table 4 shows the number and percent of vehicles in the test group and control group by make (manufacturer). The data in Table 4 are presented graphically in Figure 2. As may be seen, the proportion of vehicles for the test and control groups are reasonably well equated across manufacturers. In general, Chrysler Corporation provides more fleet vehicles to industry than the other manufacturers do, which accounts for the greater number of Chrysler products in the sample relative to the other manufacturers.

Vehicle Size

Table 5 presents the distribution of vehicles by size category for the test and control groups. The numbers also are displayed in Figure 3 for visual comparison. As may be seen, most vehicles (88 percent for test; 79 percent for control) were in the intermediate or compact category. Representative models in that category are the Chrysler Dodge Dart, Ford Maverick, General Motors Chevrolet Nova and the American Motors Hornet.

Seven percent of the test group and ten percent of the control group consisted of "full-size" vehicles. Examples of full-size vehicles are the Chrysler Plymouth Fury III, Ford LTD, General Motors Buick Electra, and American Motors Ambassador. Of the test group, five percent were sub-compacts. Of the control group, eleven percent were sub-compacts. Representative models in that category are the Ford Pinto, General Motors Chevrolet Chevette, and American Motors Gremlin.

TABLE 4

NUMBER (N) AND PERCENT (%) OF VEHICLES IN THE TEST GROUP AND CONTROL GROUP BY MAKE (MANUFACTURER)

	Test		Control	
	N	%	N	%
American Motors	492	19.9	711	24.3
Chrysler	853	34.6	935	32.0
Ford	527	21.4	651	22.2
General Motors	478	19.4	510	17.4
Other	117	04.7	120	04.1
Total	2,467	100.0	2,927	100.0

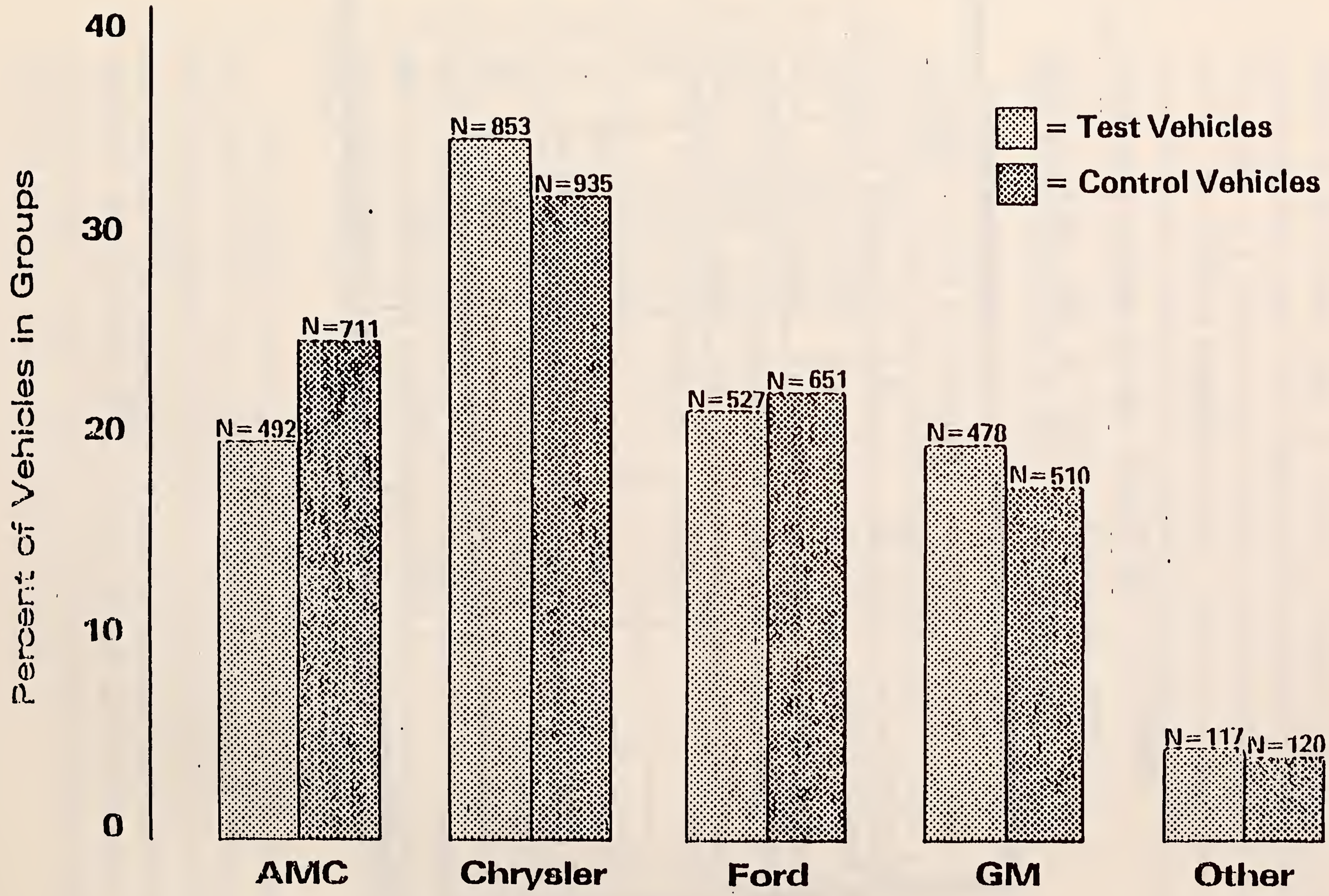


FIGURE 2--**Composition of Test and Control Groups by Vehicle Manufacturers**

TABLE 5

NUMBER (N) AND PERCENT (%) OF VEHICLES BY SIZE CATEGORY

	Test		Control	
	N	%	N	%
Sub-Compact	127	05	329	11
Intermediate/ Compact	2,162	88	2,309	79
Full Size	178	07	289	10
Total	2,467	100	2,927	100

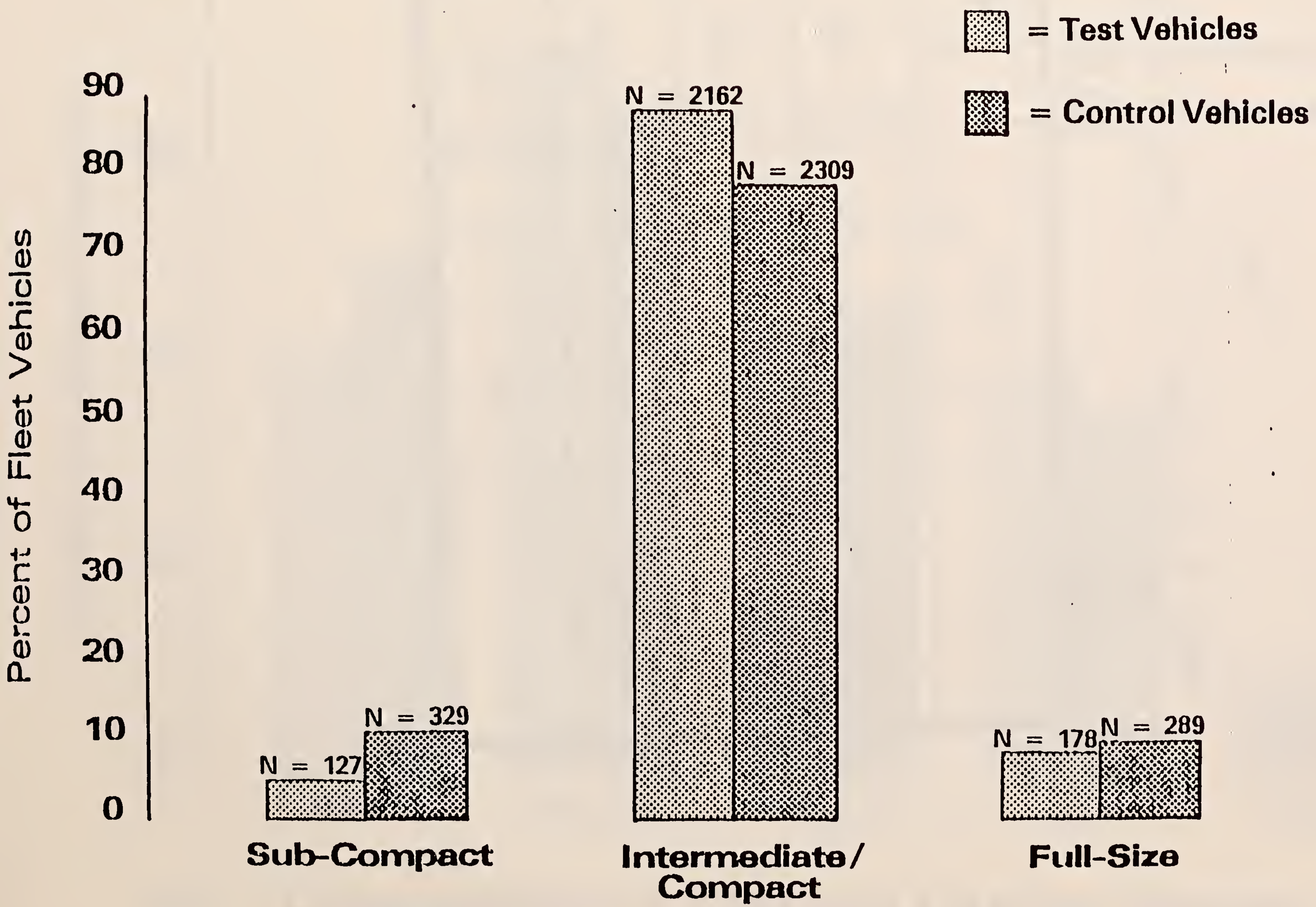


FIGURE 3 --Vehicles by Size Category

Vehicle Model Year

Table 6 and Figure 4 show the distribution of test and control vehicles by model year. As may be seen, the model years ranged from 1970 to 1979 (with the exception of 13 vehicles, 0.2 percent of the total, which were pre-1970). Model years were reasonably well equated across test and control groups with most of the vehicles in the 1972-78 model year range.

Vehicle Dispatching

More than 95 percent of the vehicles were motor pool vehicles, each available to two or more drivers upon request. The vehicle dispatchers had no knowledge of whether a vehicle was in the study or whether any vehicle being dispatched had an auxiliary stoplamp.

Accident Data Collection

The telephone companies submitted their accident data to Allen Corporation routinely by means of specially prepared forms. These forms were provided by Allen Corporation along with pre-addressed, pre-posted envelopes. Allen Corporation received and processed the accident data continuously over the twelve-month data collection period.

In addition, two on-site, direct audits of the telephone company accident report files were conducted by Allen researchers. One audit was done half-way through the data collection period. The other was done at the conclusion of the data collection period. The audits were performed to ensure the completeness and accuracy of the data submitted under the routine system. All data collected were sanitized (names and personal identifiers deleted) to protect the privacy of the persons involved.

Exposure (Mileage) Data

The participating telephone companies collected odometer readings quarterly. These data were submitted to Allen Corporation. Allen Corporation then examined the readings for completeness, verified the

TABLE 6

NUMBER (N) AND PERCENT (%) OF VEHICLES BY MODEL YEAR

	Test		Control	
	N	%	N	%
Pre-1970	0	0.0	13	0.5
1970	73	3.0	90	3.1
1971	114	4.6	150	5.1
1972	217	8.8	383	13.1
1973	335	13.6	449	15.3
1974	362	14.7	230	7.9
1975	305	12.3	285	9.7
1976	331	13.4	361	12.3
1977	465	18.8	642	21.9
1978	253	10.3	308	10.5
1979	12	.5	16	0.6
Total	2,467	100.0	2,927	100.0

readings were for study vehicles, clarified any questions by discussion with the appropriate company and, finally converted the odometer readings to vehicle miles traveled. There were more than 20,000 odometer readings involved.

Period of Data Collection

Accident and mileage data were collected continuously from 1 January 1979 through 31 December 1979.

Classification of Accidents as Relevant or Non-Relevant

An accident was defined as "a harmful event to a study vehicle in which the study vehicle was being operated by a driver." This definition excluded accidents in which the study vehicle was parked and unattended.

Obviously not all accidents would be relevant to the present study just because the rear of a study vehicle was involved. That is, to be relevant, an accident must be such that it is reasonable to expect that the rear lighting/signaling of the struck vehicle would have been a factor. Consistent with the previous study (8), a relevant accident was defined as an accident in which (1) the front of the striking vehicle struck the rear of the study vehicle; (2) there was at least some residual vehicle deformation or visible evidence of contact to the study vehicle; or (3) the struck (study) vehicle was either stopped, stopping (decelerating) or moving slowly prior to impact, i.e., maneuvers associated with depressing the brake pedal and illuminating the stoplamps.

Accidents were sorted initially into two categories, "relevant" and "other." All sorting was done without knowledge of the vehicle's membership in either the test or control group. Once the "other" category was compiled, those accidents were further (blind) classified as "non-relevant rear-end" and "non-relevant, non-rear-end" or simply "non-relevant other." Ideally, any differences between test and control accident rates for the non-relevant categories should not be statistically significant. Once classified, the accident vehicle report numbers were looked up in a master

list and identified as being either test or control vehicles. Accident frequencies and mileage for test and control groups were then converted to accident rates for relevant rear-enders, non-relevant rear-enders, and non-relevant non-rear-enders.

Results

Table 7 shows the number of vehicles, mileage and accident rates for the test and control groups. There were 2,467 test vehicles and 2,927 control vehicles for a total of 5,394 study vehicles. There were more control vehicles than test vehicles for the following reason. Subsequent to the original production run of auxiliary stoplamps, a group of additional vehicles was offered for the study by the C&P Telephone Company. Those vehicles were logged into the study with the intent of procuring additional lamps and equipping half of the vehicles with an auxiliary lamp. Unfortunately, time and cost prohibited the procurement and installation of additional lights, as the study was within a week or so of its official start for data collection. The vehicles were, therefore, continued in the study as part of the control group.

Total vehicle mileage for the test group was 26,337,592. For the control group the mileage was 28,458,130. Total vehicle mileage for the two groups combined was 54,795,722. The average mileage for test vehicles was 10,676 miles. The average mileage for control vehicles was 9,723.

There were 16 relevant rear-enders for the test group as compared to 37 for the control group. Dividing these accident frequencies by the group mileage, the rates were 0.61 relevant accidents per million miles for the test group and 1.30 relevant accidents per million miles for the control group. To express the difference in relevant rear-end accident rates between test and control as a percentage reduction in the test group, we subtract 0.61 from 1.30, obtaining 0.69, and then divide 0.69 by 1.30. The result is 0.53, or a 53 percent reduction in relevant rear-enders in the

TABLE 7

NUMBER OF VEHICLES, MILEAGE, ACCIDENT FREQUENCIES
AND ACCIDENT RATES OF STUDY VEHICLES

	Test	Control	Total
No. of Vehicles	2,467	2,927	5,394
Miles Driven	26,337,592	28,458,130	54,795,722
Relevant Rear-Enders*	16 / 0.61	37 / 1.30	53 / 0.97
Non-Relevant Rear-Enders*	5 / 0.19	6 / 0.21	11 / 0.20
Non-Relevant Other Than* Rear-End Accidents	97 / 3.68	85 / 2.99	182 / 3.32
All Non-Relevant Accidents*	107 / 3.87	91 / 3.20	193 / 3.52
All Accidents*	118 / 4.48	128 / 4.50	246 / 4.49

Z_{REL} = 2.56 Significant $p < .01$ For Relevant Accidents

$Z_{NON\text{-}REL}$ = 1.32 Non-Significant for Non-Relevant Accidents

* Frequency / Rate per Million Miles

test group as compared to the control group. This result is shown in Figure 5. This difference is statistically significant (Z = -2.56) beyond the .01 level of confidence[1] (see Appendix B for a description of the statistical methodology).

Accident Rates by Make of Vehicle

Relevant test and control accidents were identified by the make (manufacturer) of the vehicles involved using the Chi-Square statistic. Observed accident frequencies were compared to expected frequencies based on the percentage of vehicles by manufacturer constituting the test and control groups respectively. Neither in the test group nor in the control group did the observed accident frequencies differ significantly from the expected frequencies. That is, in both the test and control groups, the accident frequency for a given manufacturer was proportional to the proportion of vehicles in the group for that manufacturer. Therefore, one would not be justified in attributing the observed difference in relevant accident rates between the test and control groups to a make of vehicle.

Accident Rate by Model Year

Relevant accidents were identified for test and control vehicles by model year. When the percentage of total vehicles in either the test or the control group was factored into accident frequencies for model years, no difference was seen that would suggest a disproportionate accident rate for any model year.

Estimated Cost to Repair Vehicles in the Relevant Accidents

Estimated costs and, where available, actual costs to repair vehicles were requested from the telephone companies as part of the routine data collection procedure. The only data reported, however, were estimates of repair costs and those were not available for all accidents. Moreover,

[1] Pyne, D.A., Single Variable Poisson Regression: A Goodness of Fit Test and Comparison of Regression Coefficients. Journal of the American Statistical Association, Vol. 74, p. 489-493, 1979.

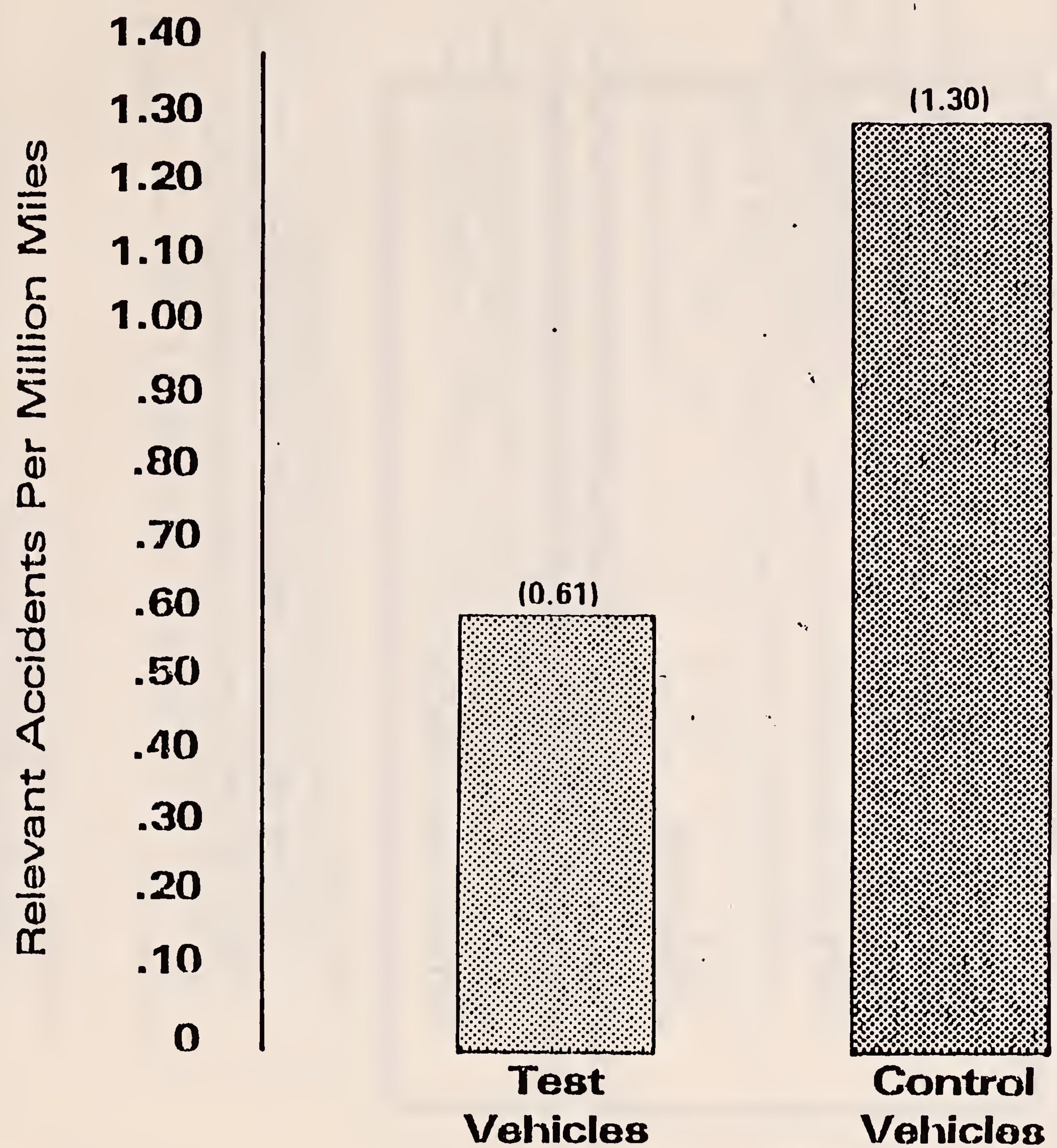


FIGURE 5--**Comparison of Relevant Accident Rate for Test and Control Groups**

the accuracy of the reported estimates is not known. Estimates of repair costs are subject to wide variability among estimators. Repair costs also vary widely from one locale to another and even within locales. Finally, the number of cost estimates reported are too few to evaluate statistically. With the foregoing caveats in mind, a summary of the cost data obtained for relevant accidents is presented in Table 8. As may be seen, the mean estimated cost to repair a test vehicle was $134 (n=9) as compared to $314 (n=16) for a control vehicle. The mean estimated cost to repair vehicles which had struck a test vehicle (i.e., cost to "other" vehicle) was $350 (n=9). The corresponding figure for the control group was $257 (n=19).

The lower part of Table 8 shows mean estimated cost to repair vehicles per accident. The figure is derived by finding the average cost per vehicle per accident and then multiplying by two, since there were two vehicles in each accident. The result for test group accidents is $484 (n=18). For the control group it is $566 (n=35).

Injury Data

Accident injury data were requested as part of the routine data collection procedure. No serious injuries were reported for the fifty-three relevant accidents in the study. There were four reports of minor injury for the relevant control accidents and one such report for the relevant test accidents.

Characteristics of Drivers of the Study Vehicles

The age and sex of drivers of the study vehicles involved in relevant accidents were reviewed. No pattern was evident to suggest that either variable was of relevance to a study vehicle being struck in the rear.

Accidents by Time of Day

All of the vehicles in the study were business vehicles and were operated mainly during normal business hours. Most of the driving was

TABLE 8

AVERAGE COST TO REPAIR BASED ON AVAILABLE ESTIMATES

(N = Number of Reported Cost Estimates)

	Test Group	Control Group
Average Cost for Company Vehicle	\$ 134 N = 9	\$ 314 N = 16
Average Cost for Other Vehicle	\$ 350 N = 9	\$ 257 N = 19
Average Cost Per Accident*	\$ 484 N = 18	\$ 566 N = 35

*Average Cost Per Accident = Average Cost Per Vehicle Per Accident x 2 Vehicles Per Accident.

done between six o'clock in the morning and six o'clock in the evening. Some driving was done later at night.

Figure 6 presents the frequency of test and control vehicle accidents by time of day. In the figure, the day is divided into six periods of four hours beginning at midnight (12:00 a.m.) and ending at 11:59 p.m. As may be seen, there were less accidents in the test group than in the control group for each of the six periods. It may be noted also that from 6:00 p.m. to 5:59 a.m. there were no accidents in the test group whereas there were five accidents in the control group. If one includes the early morning period, from 6:00 a.m. to 9:59 a.m., the frequencies are two for the test group as compared to eleven for the control group. This suggests that the auxiliary stop-lamp may be even more effective at dawn, dusk and night than in the day-time. A similar result was reported in the preceding study (8).

Accident Rates by Telephone Company

Six of the seven participating telephone companies showed a reduction in relevant rear accidents in the test group as compared to the control group. The single exception was a company that reported very few accidents overall, and, of which, only two were classified as relevant (one test, one control).

The reduction in relevant rear-enders for the test group ranged from a high of sixty percent for a large urban fleet to a low of fourteen percent for a more geographically distributed fleet.

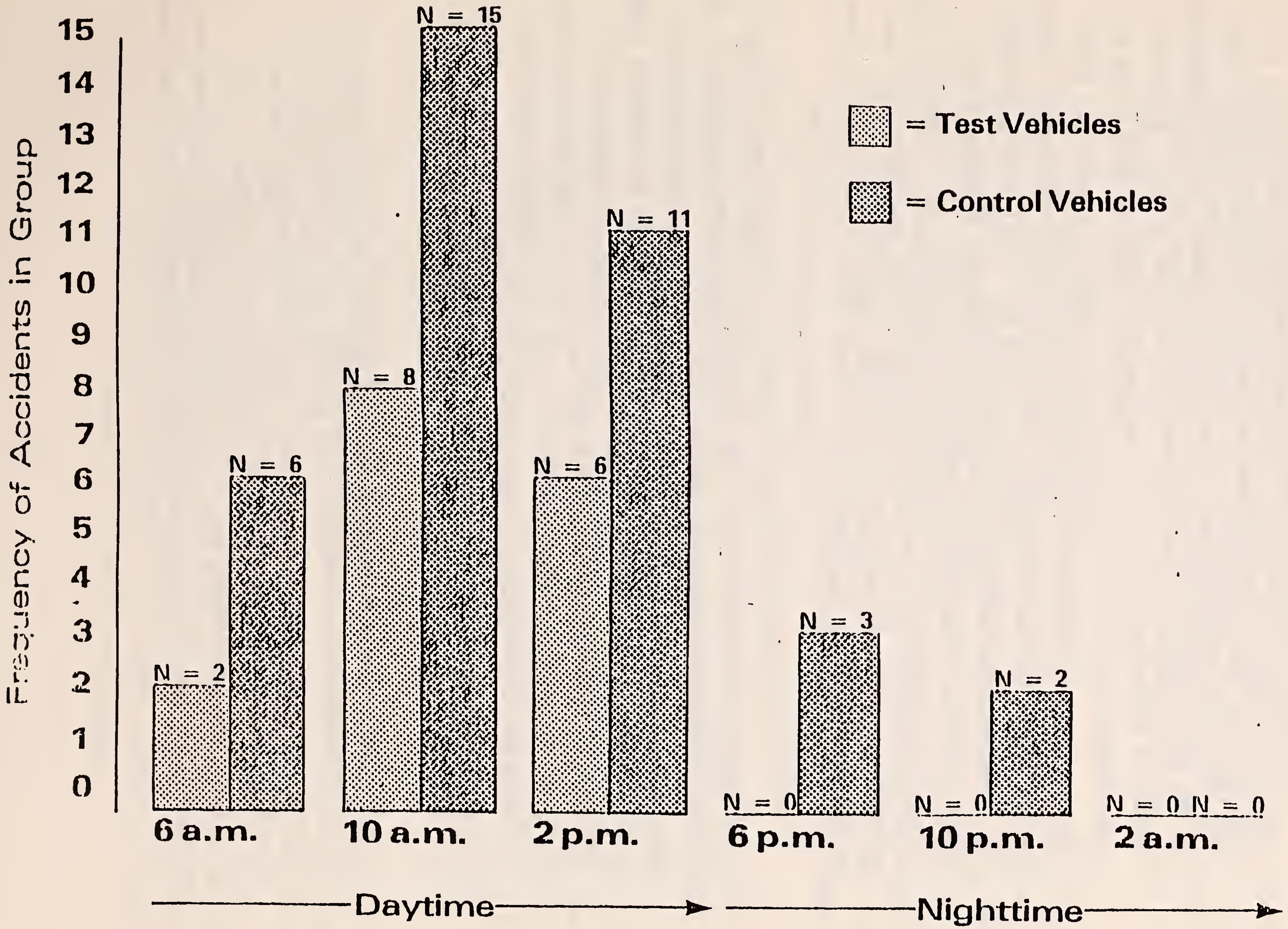


FIGURE 6 -- **Frequency of Relevant Accidents by Time of Day for Test and Control Group**

Discussion

General Comments

The results of this field evaluation indicate that use of an auxiliary, center, high-mounted stoplamp significantly reduces rear-end impacts to passenger cars. This effect appears to be independent of the make, model and year of vehicle, and time of day. A possible exception regarding time of day, however, is that the effect may be even greater at night. That possibility, which is consistent with the results of the previous study (8), would be of considerable importance since a greater proportion of severe and fatal injury accidents are known to occur at night, especially Friday and Saturday nights after 11:00 p.m. The absolute number of accidents in the present study is small but, even so, the positive effect of the auxiliary lamp was observed consistently across vehicle makes, models, model years, time of day and telephone companies.

Since the present study was an effort to validate the findings of a previous investigation (8), a few comparisons between the results of the two studies would appear to be in order. First, the magnitude of the reduction in relevant rear-end accidents found in the present study was 53 percent. The reduction reported in the earlier study was 54 percent. Both studies suggest that not only the rate of rear-end accidents is decreased but that the cost is less for accidents that occur involving the test vehicles. Both studies also suggest that the effectiveness of the auxiliary stoplamp may be even greater at night and in the hours of dawn and dusk.

An important difference between the present and the previous study is in the population of drivers used and the nature of their driving. The previous study (8) used taxicabs. Cab drivers operate routinely in highly congested areas (airports, bus and train terminals, city streets). The cab drivers are, in our opinion, aggressive drivers who change lanes, turn, and stop more abruptly and more often than the average

driver does. In part, this is due to seeking, picking up and discharging fares, and in attempting to complete each run quickly. Cabs, moreover, do not generally shuttle between specific locations familiar to them. So, in responding to a call, they often must search for an address and the associated driving is of an uncertain, stop-and-go nature. Such is the nature of taxicab operations.

The population of drivers in the present study is quite different, however. They are not under the pressure of being paid by the mile, minute, or meter. They do not routinely operate in congested areas as do taxicabs. Their driving patterns conform much more to the general public than does the pattern of cab drivers. The telephone company drivers use much less "hunting" behavior in that they do not seek passengers from the street nor do they search for a high number of unfamiliar addresses (relative to taxicab drivers).

The present population of drivers is, in our judgment, a very safety conscious and conservative group. Accident reporting is compulsory and safe driving is a fundamental requirement of continued employment. As such, the accident rate for telephone company vehicles is lower than for the general public. They have relatively few drivers under age twenty or over age fifty-five. They operate for business purposes and they drive mainly during daytime business hours. Walk-around inspection of each vehicle is mandatory prior to a driver's taking the vehicle out of the garage or off of the company lot.

Thus, in more respects, the sample of drivers and vehicles in the present study would seem to have provided a stringent test of the possible benefit of the auxiliary stoplamp. In fact, one may wonder how the lamp could show a fifty percent reduction in relevant rear-enders, as was found. Much of the answer lies in the nature of the accidents involved--even the most defensive of drivers is vulnerable to impact from the rear. And so, to find a reduction in relevant rear-enders similar to that found with taxicabs is not as unusual as it might first appear.

It may be noted also that the previous study (8) used full-sized vehicles, all of which were Chrysler products. Theoretically, the effect observed in that study might have been limited to vehicles of that manufacturer, possibly because of the O.E.M. configuration of the taillights in the control group. The present results, however, indicate that the effect holds for all of the major U.S. vehicle manufacturers and across a wide range of model years (1970-1979).

In sum, the driver populations used in the taxicab and the telephone company fleets would appear as extremes that bracket the driving public fairly well, with the exception of (1) recreational driving, (2) alcohol involvement, and (3) young (age 16-20) or elderly (age 55 and beyond) drivers. In our opinion, the benefit of the auxiliary stoplamp observed in the present study is a conservative estimate of its true potential for reducing rear-end accidents.

Possible Reasons for the Observed Effect

In the vehicle signaling and lighting community, there has been much discussion as to why a given configuration of lamps would or would not be an improvement over existing designs. By and large, laboratory and simulation investigations have been inconclusive. Controlled driving studies have not been much more encouraging. One reason for the lack of results is that, in a laboratory or controlled driving experiment, one must control the risk to the subject drivers. Therefore, the driver is not exposed to the normal, day-in and day-out hazards of driving. In addition, most subjects in an experiment consider the activity as a test of their abilities. Therefore, they are alerted and they are generally on their best behavior. The foregoing conditions tend to eliminate the potential "alerting" function of a novel stoplamp configuration in a controlled experiment. Thus, the study is reduced to comparing driver reaction times for different displays, with the reactions made by attentive subjects. Once signal intensity is above threshhold, however, it is difficult to demonstrate significant differences in reaction time due to test conditions. Attention-sharing studies (in which the driver is presumably distracted by secondary tasks) attempt to get around this problem

but, nevertheless, they too are conducted on "alerted" subjects. A large field study, however, offers some relief from these constraints and thus may be more likely to reveal effects that are otherwise masked. This appears to be true for the present study and the taxicab study.

Another question is why a single high-mounted auxiliary stoplamp would be effective where dual high-mounted lamps apparently are not of additional value. The previous study evaluated dual high-mounted lights and there is sparse data on O.E.M. dual high lights on the Buick Riviera and Oldsmobile Toronado. In the foregoing situations, the dual high-mounted lamps were completely redundant to the standard lamps, functionally, and in terms of essential visual geometry. The single center high-mounted stoplamp, however, has certain unique properties.

First, it is an unambiguous signal that the vehicle's brake pedal is being depressed. The auxiliary lamp never serves as a presence or turn signal. Whereas standard lamps, at night, require the following driver to detect an increase in brightness as the signal for brake pedal depression, the single lamp merely requires detection of its luminosity. One may argue that in daytime both the single auxiliary lamp and the O.E.M. lamps operate the same way, especially where the turn signals are separate and of a different color. Yet, there is still a degree of ambiguity because, during the early morning and at dusk, in rain, haze, or fog, some vehicles will be running with their presence lamps on while others will not. In Florida, for example, use of headlights is mandatory when it is raining sufficiently hard to require use of the windshield wipers. Thus, without observing an increase in taillight brightness when it occurs, an element of doubt remains.

While one may argue also that many vehicles do separate brake, presence and turning functions by using more compartments in the standard taillight assembly, the issue remains as to whether that arrangement provides sufficient physical separation of the lamps to adequately reduce

ambiguity or misperceptions. The present study, however, clearly provided adequate physical separation of the stoplamp function.

Moreover, the auxiliary lamp is located centrally and at eye level in the following driver's forward field of view. When a following driver looks ahead through the backlight and windshield of the vehicle ahead of him to monitor traffic still further ahead, the center high-mounted lamp is very close to his foveal field of view. Thus, he may be able to detect and respond to the center lamp sooner and more often than he would for standard brake lamps. This concept of placing vehicle control information optically in the operator's line of sight has long been used in aircraft by means of the so-called "heads-up" display system.

Temporary Effect vs Lasting Effect

It may be argued that any additional lamp represents merely a novelty that attracts the attention of the following driver and which in time will diminish, especially if all passenger vehicles are thus equipped. A corollary argument is that, even if there is a true informational benefit afforded by the auxiliary lamp (and its attendent influence on rear lighting geometry), people will merely adjust by trading the benefit for closer following distances or higher following speeds, thereby maintaining a risk consistent with that which prevailed before the auxiliary lamp was used.

An opposing view is that the experimental configuration reduces present ambiguity and provides meaningful information to the following driver. It may be asserted further that drivers will not adjust to the information by increasing their risks since those drivers already drive at the upper limit of speed and following distance combinations.

Still another possibility to consider is "novelty vs learning." Perhaps there is a novelty effect, but equally likely there is ignorance

of the general presence and purpose of the lamp. It may be that, while there may be diminishing benefit due to novelty, there also may be a compensatory effect due to more effective detection and processing of the signals based on experience. The opinion of the present writers is that the effect will prove to be lasting because the lamp configuration (not just the auxiliary lamp alone) provides essential information that is, at present, absent, ambiguous, or in a less than optimal visual location. While it is reasonable to assume that some drivers may trade the benefit to maintain constant risk, we believe the majority of drivers will not do so.

Conclusions

The following conclusions are drawn from the results of this study.

1. The use of a single center, high-mounted, auxiliary stoplamp reduces relevant rear-end accident rates by slightly more than half. The effect is statistically significant beyond the .01 level of confidence.

2. The results hold across vehicle makes, models, model years and time of day. The positive effect, however, may be even greater at night.

3. The present results agree with the previous study (8), of which the present research represents an extensive field evaluation and validation of the effect of the auxiliary stoplamp.

4. The benefit of the auxiliary lamp, as observed in the present study, is judged to be conservative in that the drivers in this study were responsible persons driving in pursuit of their business primarily during business hours. Also, the sample contained very few drivers under age 20 and over age 55.

5. The results suggest that when relevant rear-end accidents do occur to vehicles equipped with the auxiliary stoplamp, the cost to repair the vehicle is less than for a vehicle not so equipped. The data, however, are insufficient for statistical verification of this indication.

Recommendations

Based on the results of the present study considered separately and in relation to the results of the preceding study (8) which were validated in the present investigation, it is recommended that the NHTSA analyze and project the results of these studies to the driving public in general and consider the significant reduction in rear-end accidents that might be achieved if all passenger vehicles were equipped with the center high-mounted auxiliary stoplamp.

APPENDIX A

REFERENCES

(1) Goldrath, B. S-F's Yellow Cabs Test "Cyberlite." Commercial Car Journal, November 1972, 100-101.

(2) Mortimer, R.G. Field test evaluation of rear lighting deceleration signals: I-Analytical and experimental studies, Interim Report, Contract DOT-HS-6-0-1447. DOT Report No. MS-805-061. March 1979.

(3) Reilly, R.E. et al. The translation of visual information into vehicular control actions. BioTechnology, Inc. Report 65-2, Rear-end Collision Research, Department of Highways, Commonwealth of Virginia and U.S. Bureau of Public Roads, October 1965.

(4) Reilly, R.E. and Cameron, B.J. Driver judgment and decision making in overtaking and passing situations. Office of Research and Development, Bureau of Public Roads, Federal Highway Administration, Department of Transportation, Washington, D.C., May 1969.

(5) Rutley, K.S. and Mace, D.G.W. An evaluation of a brakelight display which indicates the severity of braking. Ministry of Transport, Road Research Laboratory, Report LR287, 1969.

(6) Voevodsky, J. Rear-end collisions reduced: A large-scale experiment under natural conditions. Society of Automotive Engineers, Report No. 740614, August 1974.

(7) Schmidt-Claussen. Improvement of the rear light signal pattern on motor vehicles by supplemental high-mounted stoplamps. Technical Report, Westfalische Metall Industire KG, Hueck & Co., 1975.

(8) Kohl, J.S. and Baker, C. Field test evaluation of rear lighting systems. Essex Corporation, Report on Contract No. DOT-HS-5-01228, February 1978.

Analysis of Accident Data

In analyzing the number of accidents that occur in a study, three basic discrete probability distributions can be used to describe the data and, subsequently, suggest appropriate statistical tests. These three distributions are: the binomial, the Poisson, and the negative binomial.

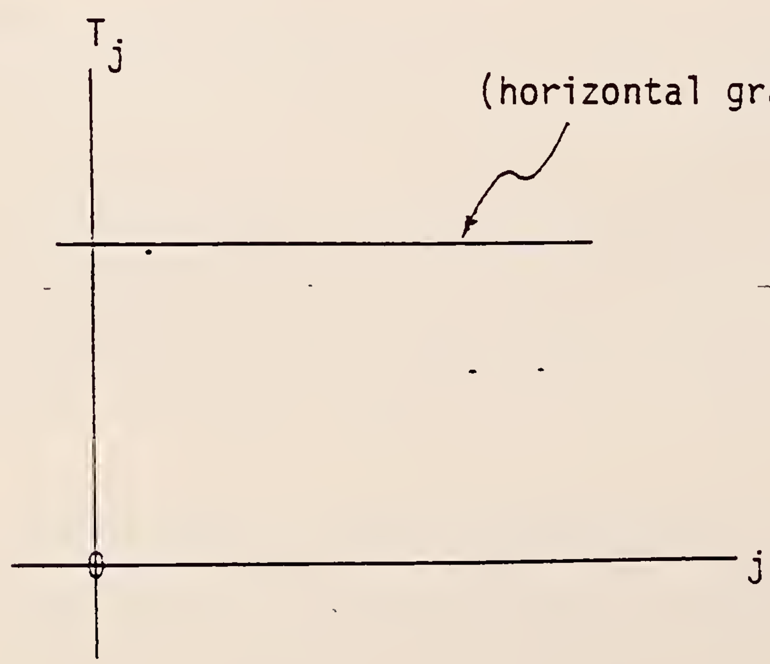
To determine which distribution is appropriate, one may use a test as given in <u>Discrete Distributions</u>, Johnson and Katz, Wiley-New York, 1969. They propose a clear way of discriminating among the three kinds of distributions by considering the sequence of

value $T_j = (j + 1)\, P_{j+1}/P_j \qquad (j = 0, 1, 2, ..)$

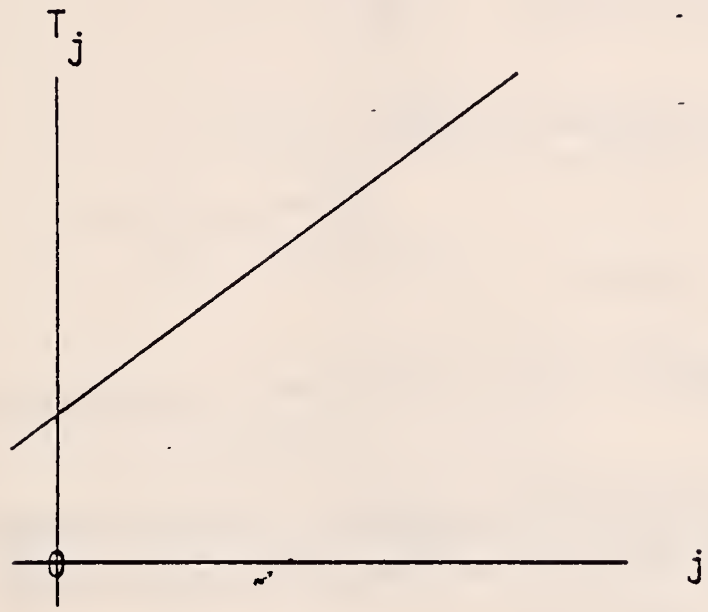
where j is the number of accidents occurring in each observational unit (a car in this study) and P_j is the proportion of units having j accidents.

If T_j is graphed against j, three possibilities occur, each indicating a distribution to be used in describing the data.

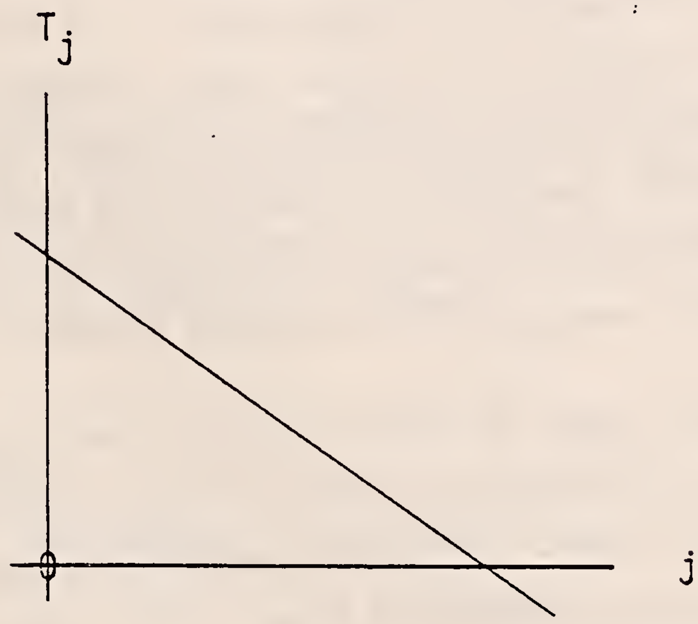
If Poisson, the slope is equal to zero.



If negative binomial, the slope is positive.

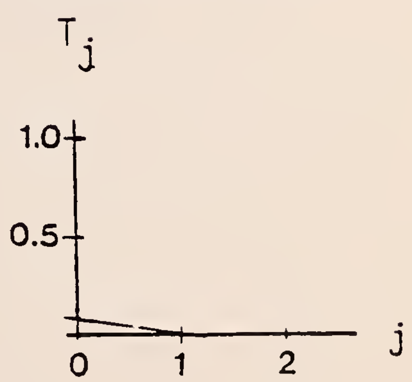


If binomial, the slope is negative.



For the <u>test</u> group in this study (relevant accidents) the values of Tj are:

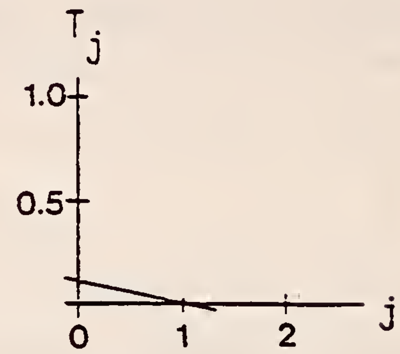
$\underline{j}$	$T_j = (j + 1)\ P_{j+1}/P_j$
0	.0065
1	.0000



The test group distribution tends toward binomial, but could be Poisson. However, it is definitely not negative binomial.

For the control group:

j	T_j
0	.0128
1	.0000



also tending toward binomial, but is definitely not negative binomial.

Since there is a tendency toward the binomial being the appropriate distribution and the proportion of accidents in both groups is very small, the Poisson model can be used. This decision stems from the knowledge that the Poisson is a very good approximation for a binomial distribution with a small probability of occurrence. In fact, in situations such as this it is strongly suggested that a Poisson model be used. Since the graphs of T_j are not pronounced in their decreasing shape and the rates are small, one can feel comfortable with the use of Poisson methodology. One salient result of the test is that the phenomenon is definitely not amenable to a negative binomial model.

In a situation such as this, when the data are not clearly Poisson (could be binomial) a test is suggested by Pyne ("Single Variable Poisson Regression; A Goodness of Fit Test and Comparisons of Regression Coefficients" Journal of the American Statistical Association, Vol. 74, p. 489-493, 1979). This test is given as:

$$Z = (\hat{\lambda}_1 - \hat{\lambda}_2) \Big/ \left[\hat{\lambda}\left(\frac{1}{x_{1+}} + \frac{1}{x_{2+}}\right)\right]^{1/2}$$

where

$\hat{\lambda}_1 = y_{1+}/x_{1+}$ (the accident rate for the test group)

$y_{1+} = 16$ (sum of accidents)

$x_{1+} = 2633.76$ (the sum of the miles driven by the test vehicles in ten thousand mile units)

$\hat{\lambda}_2 = y_{2+}/x_{2+}$ (accident rate in the control group)

$y_{2+} = 37$

$x_{2+} = 2845.81$ (in ten thousand miles units)

and $\hat{\lambda} = (y_{1+} + y_{2+}) \Big/ (x_{1+} + x_{2+})$

For large samples (such as in this study), it has been shown that Z has a normal distribution with a mean of "0" and a standard deviation of "1." A significant difference in accident rates will be accepted if Z departs from "0" to an appropriate degree.

Results

Test group

$y_{1+} = 16$ $x_{1+} = 2633.76$

$\hat{\lambda}_1 = .0061$

Control group

$y_{2+} = 37$ $x_{2+} = 2845.81$

$\hat{\lambda}_2 = .0130$

$\hat{\lambda} = (y_{1+} + y_{2+})/(x_{1+} + x_{2+})$

$\hat{\lambda} = (16 + 37)/(2633.76 + 2845.81)$

$\hat{\lambda} = .00967$

$Z = (.0061 - .0130)/\left[.00967\ (.00038 + .00035)\right]^{\frac{1}{2}}$

$= -2.56$

For the standard normal distribution, the critical value on the left side of the distribution for a critical region of 1% ($\alpha = .01$) is $Z = -2.33$. Thus, there is a significant difference in the two accident rates with the test group being the smaller.

Test for non-relevant accidents:

$y_{1+} = 102$ (accidents in test group)

$x_{1+} = 2633.76$ (mileage in test group in ten thousand mile units)

$y_{2+} = 91$ (accidents in control group)

$x_{2+} = 2845.81$ (control group mileage)

$\hat{\lambda}_1 = 102/2633.76$ (test accident rate)

$= .0387$

$\hat{\lambda}_2 = 91/2845.81$ (control accident rate)

$= .0320$

$$Z = (\hat{\lambda}_1 - \hat{\lambda}_2) \Big/ \left[\hat{\lambda}\left(\frac{1}{x_{1+}} + \frac{1}{x_{2+}}\right)\right]^{\frac{1}{2}}$$

$$\hat{\lambda} = (y_{1+} + y_{2+}) \Big/ (x_{1+} + x_{2+})$$

$$= (102 + 96) \Big/ (2633.76 + 2845.81)$$

$$= .0352$$

Thus

$$Z = (.0387 - .0320)/(.00507)$$

$$= 1.32$$

If $\alpha = .05$ $\quad Z_c = -1.65 < 1.32$

and the difference in non-relevant accident rates is not significant.

1. Name: MOSHE BEN-AKIVA
Date of Birth: June 11, 1944

2. Title: Professor of Civil Engineering

3. Area(s) of Specialization: Transportation Systems Analysis

4. Year joined MIT Faculty: 1973

5. Degrees:

   B.S., Civil Engineering, Technion-Israel Institute of Technology, 1968
   S.M., Civil Engineering, MIT, 1971
   Ph.D., Transportation Systems, MIT, 1973

6. Current Departmental and Institute Assignments:

   Graduate Officer: Transportation Systems Division
   Admissions Officer: Transportation Systems Division
   Chairman: MIT Transportation and Parking Committee
   Admissions Officer: Center for Transportation Studies

7. Current Major Research Projects:

   Monitoring Intercity Travel Characteristics
   Estimation of Improved Intersection Safety
   Attraction of Rail Compared with Bus
   Dynamic Models of Traffic Congestion
   Economic and Probabilistic Factors in Highway Design and Maintenance

8. Subjects taught in the last two years:

   1.201 Transportation Systems Analysis (G)
   1.202 Demand Modeling (G)
   1.205 Advanced Transportation Demand Modeling (G)
   1.242 Highway Systems Analysis and Technology (G)
   1.271 Doctoral Research Seminar in Transportation (G)

9. States in which Registered: Israel

10. Other Related Experience:

   Research and Teaching Assistant, Department of Civil Engineering, MIT, 1968-73
   Visiting Professor, Technion-Israel Institute of Technology, 1978-78
   Visiting Professor, Technion-Israel Institute of Technology, 1981-82

11. Selected Consulting Activities:

   Cambridge Systematics, Inc., 1972-present
   Ministry of Transport, Netherlands, 1973-present
   Attorney General, Massachusetts, 1985, 1986, 1987
   Electric Power Research Institute, 1985-present
   American Airlines, 1987

12. Scientific and Professional Societies:

    Transportation Research Board
    Transportation Research Forum
    Regional Science Association
    Operations Research Society of America

13. Honors and Awards:

    ORSA Transportation Science Dissertation Award (2nd prize)
    Lady Davis Fellowship as Visiting Associate Professor at the Technion-Israel Institute of Technology

Publications of MOSHE E. BEN-AKIVA

1. Books:

1. Richards, M.G. and M. Ben-Akiva, A Disaggregate Travel Demand Model, Saxon House, D.C. Heath, Westmead, England, 1975.

2. Ben-Akiva, M. and S.R. Lerman, Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, Cambridge, MA. 1985.

2. Papers in Refereed Journals:

1. Ben-Akiva, M., "Structure of Passenger Travel Demand Models", Transportation Research Record 526, 1974.

2. Ben-Akiva, M. with F.S. Koppelman, "Multidimensional Choice Models:Alternative Structures of Travel Demand Models", Transportation Research Special Report 149, 1974.

3. Ben-Akiva, M. and S.R. Lerman, "Some Estimation Results of a Simultaneous Model of Auto Ownership and Mode Choice to Work", Transportation, Vol.3, No.4, 1974.

4. Richards, M.G. and M. Ben-Akiva, "A Simultaneous Destination and Mode Choice Model for Shopping Trips", Transportation, Vol.3, No.4, 1974.

5. Adler, T.J. and M. Ben-Akiva, "Joint-Choice Model for Frequency,Destination, and Travel Mode for Shopping Trips", Transportation Research Record 569, 1975.

6. Ben-Akiva, M. and M.G. Richards, "Disaggregate Multimodal Model for Work Trips in the Netherlands", Transportation Research Record 569, 1975.

7. Lerman, S.R. and M. Ben-Akiva, "Disaggregate Behavioral Model of Automobile Ownership", Transportation Research Record 569, 1975.

8. Atherton, T.J. and M. Ben-Akiva, "Transferability and Updating of Disaggregate Travel Demand Models", Transportation Research Record 610, 1976.

9. Ben-Akiva, M. and T.J. Atherton, "Methodology for Short Range Travel Demand Predictions", Journal of Transport Economics and Policy, Vol.XI, No.3, 1977.

10. Ben-Akiva, M. and T.J. Atherton, "Choice Model Predictions of Carpool Demand: Methods and Results", Transportation Research Record 637, 1977.

11. Ben-Akiva, M., L. Sherman and B.C. Kullman, "Disaggregate Model of Non-Home Based Travel", Transportation Research Record 673, 1978.

12. Ruiter, E.R. and M. Ben-Akiva, "A System of Disaggregate Travel Demand Models: Structure, Component Models and Application Procedures", Transportation Research Record 673, 1978.

13. Watanatada, T. and M. Ben-Akiva, "Spatial Aggregation of Disaggregate Choice Models: An Areawide Urban Travel Demand Sketch Planning Model", Transportation Research Record 673, 1978.

14. Adler, T.J. and M. Ben-Akiva, "A Theoretical and Empirical Model of Trip Chaining Behavior", Transportation Research B, Vol.13B, 1979.

15. Watanatada, T. and M. Ben-Akiva, "Forecasting Urban Travel Demand for Quick Policy Analysis with Disaggregate Choice Models: A Monte Carlo Simulation Approach", Transportation Research A, Vol.13A, 1979.

16. Weisbrod, G.E., S.R. Lerman and M. Ben-Akiva, "Tradeoffs in Residential Location Decisions: Transportation Versus Other Factors", Transport Policy and Decision Making, Vol.1, No.1, 1980.

17. Ben-Akiva, M., C.F. Manski and L. Sherman, "A Behavioral Approach to Modelling Household Motor Vehicle Ownership and Applications to Aggregate Policy Analysis", Environment and Planning A, Vol.13, 1981.

18. Ben-Akiva, M. and N. Litinas, "Analytic Models of Trip Length Distributions", Transportation Research Record 895, 1982.

19. Chiang, Y.S., P.O. Roberts and M. Ben-Akiva, "Short-Run Freight-Demand Model: Joint Choice of Mode and Shipment Size", Transportation Research Record 828, 1982.

20. Litinas, N. and M. Ben-Akiva, "Simplified Transportation Policy Analysis Using Continuous Distributions", Transportation Research A, Vol.16A, No.5-6, 1982.

21. Salomon, I. and M. Ben-Akiva, "Life Style Segmentation in Travel Demand Analysis", Transportation Research Record 879, 1982.

22. de Palma, A., M. Ben-Akiva, C. Lefevre and N. Litinas, "Stochastic Equilibrium Model of Peak Period Traffic Congestion", Transportation Science, Vol.17, No.4, 1983.

23. Hocherman, I., J. Prashker, and M. Ben-Akiva, "Estimation and Use of Dynamic Transaction Models of Automobile Ownership", Transportation Research Record 944, 1983.

24. Salomon, I. and M. Ben-Akiva, "The Use of The Life Style Concept in Travel Demand Models", Environment and Planning A, Vol.15, 1983.

25. Ben-Akiva, M., M. Cyna and A. de Palma, "Dynamic Model of Peak Period Congestion", Transportation Research B, Vol.18B, No.5, 1984.

26. Swait, J.D., V.J. Kozel, R.C. Barros and M. Ben-Akiva, "A Model System of Individual Travel Behavior for a Brazilian City", Transportation Policy and Decision Making, Vol.2, No.4, 1984.

27. Ben-Akiva, M., M. Hirsh and J. Prashker, "Probabilistic and Economic Factors in Highway Geometric Design", Transportation Science, Vol.19, No.1, 1985.

28. Ben-Akiva, M., N. Litinas and K. Tsunokawa, "Continuous Spatial Choice: The Continuous Logit Model and Distributions of Trips and Urban Densities", Transportation Research A, Vol. 19A, No.2, 1985.

29. Ben-Akiva, M., P.P. Macke and P.S. Hsu, "Alternative Methods to Estimate Route Level Trip Tables and Expand On-Board Surveys", Transportation Research Record, 1037, 1985.

30. Gunn, H.F., M. Ben-Akiva and M.A. Bradley, "Tests of the Scaling Approach to Transferrir Disaggregate Travel Demand Models", Transportation Research Record, 1037, 1985.

31. Hirsh, M., J. Prashker and M. Ben-Akiva, "Day of the Week Models of Activity Patterns", Transportation Research Record, 1085, 1986.

32. Swait, J.D. and M. Ben-Akiva, "Constraints to Individual Travel Behavior in a Brazilian City", Transportation Research Record, 1085, 1986.

33. Ben-Akiva, M. and A. de Palma, "Some Circumstances in Which Vehicles will Reach Their Destinations Earlier by Starting Later: Revisited", Technical Note, Transportation Science, Vol. 20. No. 1, 1986.

34. Hirsh, M., J. Prashker and M. Ben-Akiva, "Dynamic Model of Weekly Activity Patterns", Transportation Science, Vol. 20, No.1. 1986.

35. Ben-Akiva, M. and A. de Palma, "Analysis of Dynamic Residential Location Choice Model with Transaction Costs", Journal of Regional Science, Vol. 26, 1986.

36. Ben-Akiva, M. and J. Swait, "The Akaike Likelihood Ratio Index," Technical Note, Transportation Science, Vol. 20, No. 2, 1986.

37. Ben-Akiva, M., A. de Palma and P. Kanaroglou, "Dynamic Model of Peak Period Traffic Congestion with Elastic Arrival Rates", Transportation Science, Vol. 20, No. 3, 1986.

38. Ben-Akiva, M., A. de Palma and P. Kanaroglou, "Effects of Capacity Constraints on Peak Period Traffic Congestion", Transportation Research Record, 1085, 1986.

39. Swait, J.D., and M. Ben-Akiva, "Incorporating Random Constraints in Discrete Models of Choice Set Generation", Transportation Research B, Vol. 21B, No.2, 1987.

40. Swait, J. D, and M. Ben-Akiva, "Empirical Test of A Constrained Choice Discrete Model: Mode Choice in Sao Paulo, Brazil", Transportation Research B, Vol. 21B, No. 2. 1987.

41. Ben-Akiva, M. A. de Palma, and P. Kanaroglou, "Dynamic Network Equilibrium: Some Comments",European Journal of Operational Research: Special Issue: Modelling Complex Systems II, Vol. 30, No. 3, 1987.

42. Hirsh, M., J.M. Prashker and M. Ben-Akiva, "New Approach to Geometric Design on Highways", Transportation Research Record, in press, 1987.

43. Train, K.E., D.L. McFadden and M. Ben-Akiva, "The Demand for Local Telephone Service: A Fully Discrete Model of Residential Calling Patterns and Service Choices," Rand Journal of Economics, Vol. 18, No. 1, Spring 1987.

44. de Palma, A., C. Lefevre and M. Ben-Akiva, "Dynamic Model of Peak Period Traffic Flows and Delays in a Corridor", International Journal of Computers and Mathematics with Applications, in press, 1987.

45. Ben-Akiva, M. and D. Bolduc, "Approaches to Model Transferability and Updating: the Combined Transfer Estimator", prepared for forthcoming publication in a Transportation Research Record, 1987.

46. Ben-Akiva, M. and D. Bolduc, "The Combined Estimator Approach to Model Transferability and Updating", submitted to Jouranl of the American Statistical Association, 1987.

3. Proceedings of Refereed Conferences:

1. Ben-Akiva, M., "A Disaggregate Direct Demand Model for Simultaneous Choice of Mode and Destination", Proceedings of the International Conference on Transportation Research, Bruges, Belgium, Transportation Research Forum, 1973.

2. Richards, M.G. and M. Ben-Akiva, "A Disaggregate Mode Choice Model for Work Trips", Proceedings of the Planning and Transport Research and Computations Summer Meeting, 1974.

3. Ben-Akiva, M., S.R. Lerman and M.L. Manheim, "Disaggregate Models: An Overview of Some Recent Research Results and Practical Applications", Proceedings of the Planning and Transport Research and Computations Summer Meeting, 1976.

4. Ben-Akiva, M. and S.R. Lerman, "Disaggregate Travel and Mobility Choice Models and Measures of Accessibility", Proceedings of the Third International Conference on Behavioral Travel Modelling, 1977, in Hensher, D.A. and P.R. Stopher (Eds.), Behavioral Travel Modelling, Croom Helm, London, 1979.

5. Ben-Akiva, M. and T. Watanatada, "Application of a Continuous Spatial Choice Logit Model", Proceedings of the NBER-NSF Conference on Decision Rules and Uncertainty, 1977, in Manski, C.F. and D. McFadden (Eds.), Structural Analysis of Discrete Data: With Econometric Applications, MIT Press, Cambridge, MA, 1981.

6. Koppelman, F.S. and M. Ben-Akiva, "Aggregate Forecasting with Disaggregate Travel Demand Models Using Normally Available Data", Proceedings of the World Conference on Transport Research, Rotterdam, Martinus Nijhoff, The Hague, 1977.

7. Ben-Akiva, M., B.C. Kullman, L. Sherman and A. Daly, "Aggregate Forecasting with a System of Disaggregate Travel Demand Models", Proceedings of the Planning and Transport Research and Computations Summer Meeting, 1978.

8. Ben-Akiva, M., M.L. Manheim and I. Salomon, "Policy Sensitive and Policy Responsive Transportation Planning", in Traffic, Transportation and Urban Planning, Proceedings of the International Conference,Tel-Aviv, 1978, International Forum Series, George Godwin, London,1981.

9. Ben-Akiva, Me,."Issues in Transferring and Updating ofTravel--Behavioral Models", Proceedings of the Fourth International Conference on Behavioral Travel Modelling 1979, in Brog, W., A.H. Meyburg and P.R. Stopher (Eds.), New Horizons in Travel Behavior, D.C. Heath, Lexington, MA, 1981.

10. Ben-Akiva, M., C.F. Manski and L. Sherman, "A Behavioral Model of Household Ownership and Use of Motor Vehicles and Its Application for Aggregate Forecasting", Proceedings of the Planning and Transport Research and Computations Summer Meeting, 1980. (An early version of a paper listed above.)

11. Bergman, M.J., M. Ben-Akiva, L.A. Silman and S.B. Pitschke, "An Analysis of Interurban Route Choice in the Netherlands", Proceedings of the Planning and Transport Research and Computation Summer Meeting, 1982.

12. Ben-Akiva, M., I. Salomon and L. Silman, "Development and Application of Individual Choice Models for Holiday Travel", Proceedings of the World Conference on Transport Research, SNV, Hamburg, 1983.

13. Ben-Akiva, M., M.J. Bergman, A.J. Daly and R. Ramaswamy, "Modelling Inter Urban Route Choice Behavior", Proceedings of the Ninth International Symposium on Transportation and Traffic Theory, VNU Science Press, Utrech, The Netherlands, 1984.

14. Swait, J.D. and M. Ben-Akiva, "Analysis of the Effects of Captivity on Travel Time and Cost Elasticities", Proceedings of the 1985 International Conference on Travel Behavior, Noordwijk, The Netherlands 16-19 April 1985,in Behavioral Research for Transport Policy, VNU Science Press, Utrech, The Netherlands, 1986.

15. Atherton, T., M. Ben-Akiva, D. McFadden and K. Train, "Micro-Simulation of Local Residential Telephone Demand Under Alternative Service Options and Rate Structures". forthcoming, North-Holland.

16. Ben-Akiva, M. "Methods to Combine Different Data Sources and Estimate Origin-Destination Matrices, paper prepared for the 10th International Symposium on Transportation and Traffic Theory, Massachusetts Institute of Technology, Cambridge, Ma. July 9-10, 1987.

17. Ben-Akiva, M. and A. de Palma "Dynamical Models of Transportation Networks", Paper prepared for presentation at the PTRC Transport and Planning Summer Annual Meeting, University of Bath England, September 7-ll, 1987.

18. Ben-Akiva,M., A.J. Daly and H.F. Gunn, "Destination Choice Models: Design and Appraisal", Paper prepared for presentation at the PTRC Transport Planning Summer Annual Meeting, University of Bath, England, September 7-ll, 1987.

19. Ben-Akiva, M. "Dynamic Network Models: Review of Recent Research", paper prepared for presentation at the PTRC Transport and Planning Annual Summer Meeting, University of Bath, England, September 7-ll, 1987.

4. Other Major Publications:

4.1 Papers:

1. Ben-Akiva, M., "Measurement of Traveller Response to Changes in Transportation System Supply", in Design of Procedures to Evaluate Traveller Responses to Changes in Transportation Supply, Conference Summary and White Papers, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1974.

2. Ben-Akiva, M. and S.R. Lerman, "Forecasting Models in Transportation Planning," Proceedings of the Conference on Population Forecasting for Small Areas, Oak Ridge Associated Universities, Oak Ridge, Tennessee,1975.

3. Terziev, M.N., M. Ben-Akiva and P.O. Roberts, "Freight Demand Modellings: A Policy Sensitive Approach", presented at the 47the National Operations Research Society of America Meeting, published as CTS Report No. 75-6, Center for Transportation Studies, MIT,Cambridge, MA, 1975.

4. Ben-Akiva, M., "Passenger Travel Demand Forecasting: Applications of Disaggregate Models and Directions for Research", Invited Paper, Proceedings of the World Conference on Transport Research, Rotterdam, Martinus Nijhoff, The Hague, 1977.

5. Adler, T.J., M. Ben-Akiva and S.R. Lerman, "Directions for Improvements in Urban Travel Forecasting Procedures", Proceedings of the Applications of New Urban Travel Forecasting Procedure Conference, Federal Highway Administration, U.S. Department of Transportation, 1978.

6. Silman, L., M. Ben-Akiva and R.R. Baron, "Forecasting Tourism Demand by Modelling Individual Choices", paper prepared for presentation at the 31 st Annual Congress of the International Association of Scientific Experts in Tourism, Cardiff, U.K., September 1981. An earlier version was presented at the 12th Annual Conference of the Travel and Tourism Research Association, Las Vegas, Nevada, June 1981.

7. Ben-Akiva, M. and A. de Palma, "Modelling and Analysis of Dynamic Residential Location Choice", Department of Economics, working paper No. 83-19, McMaster University, Hamilton, Ontario, July 1983.

8. Ben-Akiva, M., H. Gunn and H. Pol, "Expansion of Data from Mixed Random and Choice-Based Survey Designs", paper prepared for presentation at the Conference on New Survey Methods in Transport, Australia, September 1983.

9. Ben-Akiva, M., A. de Palma and P. Kanaroglou, "Capacity Restraints in Traffic Models with Elastic Demand", Proceedings of the 10th Transportation Planning and Research Colloquium, The Netherlands, 1983.

10. Hirsh, M., J.N. Prashker and M. Ben-Akiva, "Theoretical Model of Weekly Activity Pattern", Publication No. 84-049, Transportation Research Institute, Technion Israel, January. 1984.

11. Ben-Akiva, M., A. de Palma and J. Thisse, "Product Differentiation Induces Geographical Aglomeration", paper prepared for presentation at the Third International Symposium on Locational Decisions, Boston, MA, June, 1984.

12. Ben-Akiva, M., H.F. Gunn and L.A. Silman, "Disaggregate Trip Distribution Models", Invited Paper, Proceedings of the Japan Society of Civil Engineers, No. 347/IV-1 (Infrastructure Planning and Mangement), July 1984.

13. Ben-Akiva, M., "Comment on 'Inferences on Trip Matrices from Observations on Highway Volumes: A Bayesian Statisitcal Approach' by M.J. Maher", A short note, Transportation Research, Vol. 19B, No. 1, 1985.

14. Ben-Akiva, M., A. de Palma and J-F. Thisse, "Spatial Competition with Differentiated Products", Universite Catholique de Louvain, Center for Operations Research and Econometrics, CORE discussion paper No. 8517, June 1985.

15. Hsu. P.S. and M. Ben-Akiva, "Sample Designs Optimized for Cost Effective System-Wide Route Level Data Collection", working paper, 1986.

16. Ben-Akiva , M., "Dynamic Network Equilibrium Research", Proceedings of Research Conferenc Transportation Research A, Vol. 19A, No. 5-6,1985.

17. Atherton, T.J., M. Ben-Akiva, W.A. Jessiman, and R.E. Lund, "Micro-Simulation with Discrete Choice Models to Evaluate Alternative Residential Telephone Service", paper prepared for presentation at the Bell Communications Research Conference on Telecommunications, Demand Modelling, New Orleans, LA, October 23-24, 1986.

4.2 Research Reports

1. Ruiter, E.R. (ed.) Techniques for Searching Out Transport Systems Alternatives, Summary Report, Research Report R69-38, Department of Civil Engineering, MIT Cambridge, MA., 1969, (contributor).

2. Charles River Associates, Inc., Choice of Transport Technology Under Varying Factor Endowments in Less Developed Countries, Report No.CRA-3-138-30, Cambridge, Massachusetts, 1979.

3. Ben-Akiva, M., Public and Private Transportation in an Urban Corridor-The Southeast Corridor of Boston, S.M. Thesis, Department of Civil Engineering, MIT, Cambridge, Massachusetts, 1971

4. Ben-Akiva, M., Structure of Passenger Travel Demand Models, Ph.D. Dissertation, Department of Civil Engineering, MIT, Cambridge, Massachusetts, 1973.

5. Ben-Akiva, M. and M.G, Richards, Disaggregate and Simultaneous Travel Demand Models: A Dutch Case Study, Report prepared for Projectbureau Integrale Verkeers en Vervoerstudies, The Hague, The Netherlands, 1974

6. Ben-Akiva,M., S.R. Lerman, W.A. Jessiman, R. L. Albright and R.E. Nestle, A Behavioral Analysis of Automobile Ownership and Modes of Travel, prepared for Office of the Assistant Secretary for Policy, Plans and International Affairs and Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., Cambridge Systematics, Inc., Cambridge, Massachusetts, 1976.

7. Ben-Akiva, M. and T.J. Atherton, Transferability and Updating of Disaggregate Travel Demand Models, CTS Report Number 76-2, Center for Transportation Studies MIT, Cambridge, Massachusetts, 1976.

8. Ben-Akiva, M., F.S. Koppelman and T. Watanatada, Development of an Aggregate Model of Urbanized Area Travel Behavior: Phase I Report, prepared for Assistant Secretary for Policy, Plans and International Affairs and Federal Highway Administration, U.S. Department of Transportation, Washington, D.C., 1976.

9. Ben-Akiva, M. and F.S. Koppelman, Aggregate Forecasting with Disaggregate Travel Demand Models Using Normally Available Data, prepared for Projectbureau for Integral Traffic and Transportation Studies, Ministry of Transport, The Netherlands, June 3 1976.

10. Watanatada, T. and M. Ben-Akiva, Development of an Aggregate Model of Urbanized Area Travel Demand: Detailed Specification of Aggregate Travel Demand Model for Use in TRANS, technical report, Center for Transportation Studies, MIT, Cambridge, Massachusetts, 1976.

11. Suhrbier, J.H., T.J. Atherton, W.A. Jessiman and M. Ben-Akiva, The Use of Disaggregate Travel Demand Models to Analyze the Energy Conservation Potential of Parking Restrictions within a Metropolitan Area, prepared for the Federal Energy Administration, Washington, D.C., Cambridge Systematics, Inc., Cambridge, Massachusetts, May 1976.

12. Ruiter, E.R. and M. Ben-Akiva, A System of Disaggregate Travel Demand Models: Structure, Component Models, and Application Procedures, final report prepared for the Metropolitan Transportation Commission, Berkeley, California, Cambridge, Systematics, Inc., Cambridge, Massachusetts, May 1976.

13. Ben-Akiva, M., T.J. Adler, J. Jacobson and M.J. Manheim, Experiments to Clarify Priorities in Urban Travel Forecasting Research and Development Final Report, prepared for Program of University Research, U.S. Department of Transportation, Washington,, D.C., 1977.

14. Roberts, P.O., M. Ben-Akiva, M.N. Terziev and Y.S. Chiang, Development of a Policy Sensitive Model for Forecasting Freight Demand: Phase I Report, Office of the Secretary, U.S. Department of Transportation, Washington, D.C., 1977

15. Watanatada, T. and M. Ben-Akiva, Development of An Aggregate Model of Urbanized Area Travel Behavior, Final Report, DOT-P-30-79-1, prepared for the U.S. Department of Transportation, Assistant Secretary for Policy, Plans and International Affairs and Federal Highway Administration, 1977.

16. Kullman, B.C. and M. Ben-Akiva, SIGMO Study Methodology: Specification and Estimation of Disaggregate Behavioral Models Used in Aggregate Forecast Systems, Report prepared by Cambridge Systematics, Inc. For Projectbureau Integral Traffic and Transportation Studies, Ministry of Transport, The Netherlands, 1977.

17. Ben-Akiva, M., S.R. Lerman, D. Damm and P. Hall, Theories, Empirical Evidence and Models of Urban Activity Patterns and Residential Location: A Literature Review, Report prepared for Program of University Research, U.S. Department of Transportation, 1978.

18. Ben-Akiva, M., S.R. Lerman, D. Damm, J. Jacobson and G. Weisbrod, Understanding, Prediction, and Evaluation of Transportation Related Consumer Behavior Phase I Report, Center for Transportation Studies, MIT, Cambridge, Massachusetts, 1978.

19. Ben-Akiva, M. and L. Sherman, Research Directions for Analyzing Recreational Activities and Travel, Patterns, prepared for Projectbureau, Ministry of Transport, The Netherlands, November 1979.

20. Ben-Akiva, M., and S. Nason, Development of a Model System to Forecast Holiday Air Travel in the Netherlands, prepared for the Civil Aviation Department, Ministry of Transport, The Netherlands, February 1980.

21. Ben-Akiva, M., S.R. Lerman, D. Damm, J. Jacobson, S. Pitschke, G.Weisbrod, and R. Wolfe, Understanding, Prediction and Evaluation of Transportation Related Consumer Behavior, Final Report, Center for Transportation Studies, MIT, prepared for Office of University Research, Research and Special Programs Administration, U.S. Department of Transportation, September, 1980.

22. Silman, L. and M. Ben-Akiva, Analysis of Holiday Patterns 1969-1978 and Collection of Da[illegible] Holiday Characteristics, prepared for Civil Aviation Department, Ministry of Transport, [illegible]d Schiphol Airport Authority, The Netherlands, December, 1980.

23. Chiang, Y.S. , P.O. Roberts and M. Ben-Akiva, Development of a Policy Sensitive Model for Forecasting Freight Demand, Final Report, CTS Report 81-1, prepared for the Office of the Secretary, U.S. Department of Transportation, 1981.

24. Silman, L. and M. Ben-Akiva, Models of Mode and Destination Choice for Holiday Trips and Thei[illegible] Application prepared for the Ministry of Transport, Federal Republic of Germany, September, 1981.

25. Regie Autonome Des Transports Parisien and Cambridge Systematics, Etudes de Politiques de Transport en Region Ile de France, June 1982.(Contributor)

26. Cambridge Systematics Europe, Travel Demand Models, Zuidvleugel Study Report 7, prepared for the Dienst Verkeerskunde, Rijkswaterstaat, The Netherlands Ministry of Transport, The Hague, 1983. (Contributor).

27. Pitschke, S.B., and M. Ben-Akiva, Analysis of Inter-Urban Route Choice in The Netherlands, prepared by Cambridge Systematics Europe for the Dienst Verkeerskunde, Rijkswaterstaat, The Hague, 1983.

28. Silman, L. and M. Ben-Akiva, Alternative Approaches to Supplementary Travel Surveys, (in Hebrew), prepared for the Ministry of Transport, Jerusalem, Israel, July, 1983

29. Cambridge Systematics Europe, Estimation and Application of Disaggregate Models of Mode a[illegible] Destination Choice, draft report prepared for the Direction Des Etudes Generales, Regie Autonome Des Transport Parisien, Paris, 1984.

30. Ben-Akiva, M.E, P. P. Macke and P.S. Hsu, Alternative Methods to Estimate Route Level Trip Tables, draft report, prepared for the Urban Mass Transportation Administration, U.S. Department of Transportation, August, 1984.

31. Busa, Guy D., M. Ben-Akiva and Oral Buyukozturk, Modelling Concrete Bridge Deck Deterioration, Draft Final Report, Submitted to the Transportation Systems Center, U.S. Department of Transportation, Cambridge, MA, June 1985.

32. Ben-Akiva, P.P. Macke and P.S. Hsu, Estimation of Trip Tables and Expansion of On-Board Surveys at the Route Level, Final Report prepared for the Urban Mass Transportation Administration, U.S. Department of Transportation, Office of Methods and Support-Methods Division, Washington, D.C., May 1985.

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ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100E

CLAIM ADJUSTMENT EXPENSE FACTOR

SUMMARY OF SCHEDULE 100E

Company .... Attorney General

Line of Business .. Private Passenger

Rates Effective ... January 1, 1988

Claim Adjustment Expense Factors

Coverage	
Bodily Injury Coverages	1.105
Property Damage Liability	1.098
Physical Damage Coverages	1.122

[redacted]

[redacted]

[redacted]

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100F

EXPENSE PURE PREMIUM

SUMMARY OF SCHEDULE 100F

Company .... Attorney General

Line of Business .. Private Passenger

Rates Effective ... January 1, 1988

Expense Pure Premium

Coverage	Company Expense	Commissions
A-1	$6.74	$8.66
A-2 PIP	1.70	3.58
B, Basic	1.23	2.09
PDL, Basic	12.72	27.30
Collision	19.88	27.83
Limited Collision	5.84	25.28
D, Medical Payments	1.40	2.28
E, Comprehensive	11.21	14.40
U	1.04	0.45

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
ADJUSTED 1987 COMPANY EXPENSE PURE PREMIUM

Coverage	(1) Provision in 1987 Rates*	(2) Trend Correction Factor#	(3) Adjustment For Excess & Optional Coverages+	(4) Adjusted 1987 Allowance**
A-1	$6.65	1.003	1.010	6.74
A-2	$1.70	1.003	1.000	1.70
B, Basic	$1.21	1.003	1.010	1.23
PDL, Basic	$12.68	1.003	1.001	12.72
Collision	$21.93	1.003	0.904	19.88
Limited Collision	$4.45	1.003	1.308	5.84
D	$1.38	1.003	1.011	1.40
Comprehensive	$11.43	1.003	0.978	11.21
U	$1.17	1.003	0.887	1.04

* 1987 Decision
\# Source: 1988 AG 100G-1
\+ Source: 1988 AG 100F-3 for A-1, B, PDL and U; 1988 AG 100F-4 for Collision, Limited Collision, D and Comprehensive.
** (4) = (1) x (2) x (3)

1988 A.G.
100F-2

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Adjusted 1987 Commission Expense Pure Premiums

Coverage	Provision in 1987 Rates*	Trend Correction Factor#	Adjustment For Excess & Optional Coverages+	Adjusted 1987 Allowance**
A-1	$8.57	1.000	1.010	$8.66
A-2	$3.58	1.000	1.000	3.58
B, Basic	$2.07	1.000	1.010	2.09
PDL, Basic	$27.27	1.000	1.001	27.30
Collision	$30.78	1.000	0.904	27.83
Limited Collision	$19.32	1.000	1.308	25.28
D	$2.25	1.000	1.011	2.28
Comprehensive	$14.72	1.000	0.978	14.40
U	$0.51	1.000	0.887	0.45

* Source: 1988 MARB 100F-2
\# Source: 1988 AG 100G
\+ Source: 1988 AG 100F-3 for A-1, B, PDL and U; AG 1988 100F-4 for Collision, Limited Collision, D and Comprehensive.
** (4) = (1) x (2) x (3)

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Factor to Adjust Allowed 1987 Expenses and Commissions
for New Increased Limits Factors

E87 = 1987 Basic Limits (company expenses or commissions)

AE87 = 1987 Adjusted Basic Limits Expenses (company expenses or commissions)

F87 = average increased limits factor underlying the 1987 rates, i.e., using the current ILFs averaged on 1985 exposures

For BI#:	0.9232	For U*:	2.5711
For PDL#:	0.0770		

F88 = average increased limits factor underlying the 1988 rates, i.e., using 1988 ILFs averaged on 1986 exposures (source: Section 101)

For BI:	0.8998	For U:	3.2258
For PDL:	0.0763		

B86 = 1986 basic limits exposures = 3,103,795 (Reference Code 01)

I86 = 1986 increased limits exposures (Reference Code 01)

For BI:	2,312,638	For U:	1,212,963
For PDL:	2,935,706		

Then:

E87 B86 + E87 F87 I86 = AE87 B86 + AE87 F86 I86

Then:

$$\frac{AE87}{E87} = \frac{B86 + F87\ I86}{B86 + F88\ I86} = \frac{3{,}103{,}795 + 2{,}312{,}638\ F87}{3{,}103{,}795 + 2{,}312{,}638\ F88} \quad \text{for BI}$$

$$\frac{AE87}{E87} = \frac{3{,}103{,}795 + 2{,}935{,}706\ F87}{3{,}103{,}795 + 2{,}935{,}706\ F88} \quad \text{for PDL}$$

Coverage	AE87/E87
BI	1.0104
PDL	1.0006
U	0.8868

* 1988 AG 100F-3, p.2.
\# 1988 MARB 100F-3.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Calculation of 1987 Increased Limits Factor
for U Coverages

Limit	1985 Exposures*	Current Excess Factor#
15/30	43,508.4	0.59
20/40	152,577.5	1.06
20/50	48,574.5	1.11
25/50	143,641.4	1.49
25/60	47,680.5	1.54
50/100	203,238.0	2.54
100/300	374,291.6	3.88
250/500	32,184.3	5.90
500/1000	1,192.0	9.35
Other	7,748.1	1.71
	1,054,636.3	2.5711

* From 1987 MARB Schedule 101E, Page 3
\# From 1988 MARB Schedule 101E, Page 3, correcting for errors in the listing of Current Excess Factors.

1988 Massachusetts Private Passenger Automobile
Factors to Adjust for Optional Coverage Purchase Patterns
Commission Expenses

Coverage	Percent Purchasing Coverage 1987 *	Projected Percent Purchasing Coverage 1988 **	Adjustment of Per-Exposure Expenses 1987/1988
Compulsory			
Collision	0.624	0.690	0.904
Limited Collsion	0.051	0.039	1.308
D	0.445	0.440	1.011
Comprehensive	0.851	0.870	0.978

* Underlying current expense base in Decision on 1987 rates.
** Source 1988 AG 100F-4, Page 2.

1988 Massachusetts Private Passenger Automobile
Projected Percent of Exposures Purchasing Optional Coverages *

Coverage	Projection Parameters A	Projection Parameters B	Projected Value 1988 Y = Ae^Bx (x=6)
Collision	0.57847	0.02944	0.690
Limited Collision	0.11931	-0.18492	0.039
D	0.50108	-0.02171	0.440
Comprehensive	0.80293	0.01334	0.870

* Calculated from data found in 1988 MARB 100F-4, page 4, using latest 4 years.

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100G

EXPENSE TREND & PROJECTION FACTOR

SUMMARY OF SCHEDULE 100G

Company .... Attorney General

Line of Business .. Private Passenger

Rates Effective ... January 1, 1988

Expense Trend and Projection Factors

Expense Trend

	Commissions	1.031
	Company Expense	1.033

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Expense Trend Factors; Expense Trend Correction Factors

	Company Expense
(1) Indicated 1987-1988 trend	
(a) Average date in 1987 rates	11/1/87
(b) Average date in 1988 rates	11/1/88
(c) Expense trend (AG 100G-2)	1.028
(2) Correction to trend in allowed 1986 expense pure premiums	
(a) Average date in 1984 benchmark	7/1/84
(b) Average date in 1987 rates	11/1/87
(c) Allowed trend 1984-86 (1986 Decision)	1.087
(d) Allowed trend correction 1984-86 (1987 Decision)	1.001
(e) Allowed trend 1986-87 (1987 Decision)	1.052
(f) Total trend in allowed 1987 expense pure premiums (c) x (d) x (e)	1.145
(g) Current trend from (a) to (b)	1.148
(h) Company expense trend correction factor (g)/(f)	1.003

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Expense Trend Factors; Expense Trend Correction Factors

	Commissions
(1) Indicated 1987-1988 trend	
(a) Average date in 1987 rates	8/8/87
(b) Average date in 1988 rates	8/8/88
(c) Expense trend (A.G. 100G-2)	1.028
(2) Correction to trend in allowed 1986 expense pure premiums	
(a) Average date in 1980 benchmark	8/1/80
(b) Average date in 1987 rates	8/8/87
(c) Allowed trend 1980-82 (1982 Decision)	1.188
(d) Allowed trend correction 1980-82 (1983 Decision)	1.019
(e) Allowed trend 1982-83 (1983-Decision)	1.075
(f) Allowed trend correction 1980-83 (1984 Decision)	1.002
(g) Allowed trend 1983-84 (1984 Decision)	1.069
(h) Allowed trend correction 1980-84 (1985 Decision)	0.980
(i) Allowed trend 1984-85 (1985 Decision)	1.046
(j) Allowed trend correction 1980-85 (1986 Decision)	0.985
(k) Allowed trend 1985-86 (1986 Decision)	1.030
(l) Allowed trend correction 1980-86 (1987 Decision)	0.999
(m) Allowed trend 1986-87 (1987 Decision)	1.041
(n) Total trend in allowed 1987 expense pure premiums* (from (a) to (b)). (n) = (c)x(d)x(e)x(f)x(g)x(h) x(i)x(j)x(k)x(l)x(m)	1.508
(o) Current indicated trend from (a) to (b); See 100G-2	1.508
(p) Expense trend correction factor (o)/(n)	1.000

* Correcting for error in 1988 MARB 100G-1.

1988 A.G.
100G-2

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Calculation of Expense Trends, Expense Trend Correction

		Company Expense#		Commissions+	
Index	Weight*	(1984-11/1/87)	(11/1/87-11/1/88)	(1980-8/8/87)	(8/8/87-8/8/88)
Avg. Weekly Earnings - Fire, Marine, Casualty	0.69	1.187	1.040	1.613	1.043
Food Away From Home	0.02	1.135	1.026	1.391	1.028
Private Transportation	0.02	0.979	0.950	1.213	0.953
Telephone	0.05	1.090	1.020	1.500	1.020
Office & Store Equipment	0.12	1.035	1.012	1.122	1.012
Paper	0.05	1.051	1.026	1.221	1.026
Postage	0.05	1.104	1.000	1.449	1.000
		1.148	1.031	1.508	1.033

* 1988 AG 100G-4, Exhibit 1.

\# 1988 AG 100G-3, p.2

\+ 1988 AG 100G-3, p.1,3.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
CALCULATION OF EXPENSE COMPONENT TRENDS FOR EXPENSE TREND FACTORS

Commissions (8/8/87 - 8/8/88)

	Average Weekly Earnings Fire, Marine, & Casualty Ins.	Food Away From Home	Private Trans.	Phone	Postage	Office and Store Machines & Equip.	Paper
(1) Fitted index value for 8/8/87	374.02	379.33	293.92	207.76	372.70	157.06	316.74
(2) Fitted index value for 8/8/88	393.48	393.61	282.57	211.96	372.70	158.89	324.90
(3) Trend Factor: (2)/(1)	1.052	1.038	0.961	1.020	1.000	1.012	1.026
(4) Adjustment for Productivity* (1986 Decision)	0.991	0.991	0.991				
(5) Adjusted Trend Factor	1.043	1.028	0.953	1.020	1.000	1.012	1.026

* As per 1987 Private Passenger Decision.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
CALCULATION OF EXPENSE COMPONENT TRENDS
FOR EXPENSE TREND FACTORS

Company Expenses (7/1/84 - 11/1/88)

	Average Weekly Earnings Fire, Marine, & Casualty Ins.	Food Away From Home	Private Trans.	Phone	Postage	Office and Store Machines & Equip.	Paper
(1) Latest Data Period	3/87	5/87	5/87	5/87	5/87	5/87	5/87
(2) Actual 7/1/84 value*	319.37	336.70	310.10	188.40	337.50	154.00	302.90
(3) Actual index value for (1)	366.89	375.50	309.10	203.50	372.70	158.60	314.50
(4) Fitted index value for (1)	366.36	376.10	296.48	206.81	372.70	156.65	314.90
(5) Fitted index value for 11/1/87	378.54	382.65	291.27	208.73	372.70	157.49	318.64
(6) Trend Factor to 11/1/87 = [(5)/(4) x (3)/(2)]	1.187	1.135	0.979	1.090	1.104	1.035	1.051
(7) Fitted index value for 11/1/88	398.02	396.92	279.93	212.93	372.70	159.31	326.79
(8) Trend factor from 11/1/87 to 11/1/88 = (7)/(5)	1.051	1.037	0.961	1.020	1.000	1.012	1.026
(9) Adjustment for productivity **	0.989	0.989	0.989				
(10) Adjusted trend factor (8) x (9)	1.040	1.026	0.950	1.020	1.000	1.012	1.026

* Average of Twelve Months Centered on Point.
** As per 1987 Private Passenger Decision.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
CALCULATION OF EXPENSE COMPONENT TRENDS
FOR EXPENSE TREND FACTORS

Commissions (8/1/80 - 8/8/87)

	Average Weekly Earnings Fire, Marine, & Casualty Ins.	Food Away From Home	Private Trans.	Phone	Postage	Office and Store Machines & Equip.	Paper
(1) Latest Data Period	3/87	5/87	5/87	5/87	5/87	5/87	5/87
(2) Actual 8/1/80 value*	232.24	272.30	252.60	136.30	257.30	141.70	259.00
(3) Actual index value for (1)	366.89	375.50	309.10	203.50	372.70	158.60	314.50
(4) Fitted index value for (1)	366.36	376.10	296.48	206.81	372.70	156.65	314.90
(5) Fitted index value for 8/8/87	374.02	379.33	293.92	207.76	372.70	157.06	316.74
(6) Trend Factor to 8/8/87 = [(5)/(4) x (3)/(2)]	1.613	1.391	1.213	1.500	1.449	1.122	1.221

* Average of Twelve Months Centered on Point.

1988 ;.3
100G-4
Exhibit 1

1988 Massachusetts Private Passenger Automobile
Expense Trend Factors
Determination of Weights Applicable to Trend Indices

Expense Item	Weight (Exhibit 2)	Relative Weight Of Specified Items	Trend Source	Weight
Salaries	35.7%	58.6%	Avg. Weekly Earning - Fire, Marine, Casualty	0.59
Employee Relations	6.2%	10.2%	Avg. Weekly Earning - Fire, Marine, Casualty	0.10
Payroll Taxes	4.0%			
Travel and Travel Items	2.3%	3.8%	CPI - Food Away from Home	0.02
			CPI - Private Transportation	0.02
Equipment	7.5%	12.3%	PPI - Office and Store Equipment	0.12
Printing and Stationary	3.0%	4.9%	PPI - Paper	0.05
Postage and Telephone	6.2%	10.2%	CPI - Postage	0.05
			CPI - Telephone	0.05
Total of Above	64.9%	100.0%		1.00
Managers and Agents	17.3%			
Advertising	2.1%			
Boards and Bureaus	2.1%			
Survey and U/W Reports	2.7%			
Insurance	0.3%			
Rent and Rent Items	5.3%			
Other Taxes	1.7%			
Miscellaneous	3.2%			
Total	99.6%			

Source: 1988 MARB 100G-4, Correcting for error in CPI - Postage weight.

1988 Massachusetts Private Passenger Automobile

Components of Company Expenses
(Best's Aggregates & Averages 1986)

	Private Passenger Automobile and Homeowners Multiple Peril	Automobile Physical Damage	Total	% Distribution
Net Premiums	53,340,178	2,369,109	55,709,287	
Managers and Agents	2.01	.85	1.96	17.3
Advertising	.27	.21	.27	2.4
Boards and Bureaus	.24	.28	.24	2.1
Surveys and Reports	.31	.32	.31	2.7
Salaries	3.98	5.51	4.05	35.7
Employee Relations	.70	.81	.70	6.2
Insurance	.03	.03	.03	.3
Travel and Travel Items	.26	.39	.27	2.3
Rent and Rent Items	.60	.63	.60	5.3
Equipment	.86	.64	.85	7.5
Printing and Stationery	.33	.43	.33	3.0
Postage and Telephone	.71	.62	.71	6.2
Payroll Taxes	.46	.43	.46	4.0
Other Taxes	.19	.18	.19	1.7
Miscellaneous	.32	1.21	.36	3.2
Total	11.27	12.64	11.33	100.0

Source: 1988 MARB 100G-4, Exhibit 2.

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100H

UNDERWRITING PROFIT ALLOWANCE

1988-AG/SRB
100H

SUMMARY OF SCHEDULE 100H

Company: Attorney General/State Rating Bureau

Line of Business: Private Passenger

Rates Effective: January 1, 1988

Underwriting Profit

Allowances*

	Allowances
Bodily Injury Liability	-12.64
Property damage Liability	- 3.98%
Physical Damage	- 2.20%
Overall*	- 6.39

*Weighted 35/30/35 for BI, PDL, and PD, respectively.

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1988 AG
Chernick Affidavit-1

PREFILED TESTIMONY OF PAUL CHERNICK

Q: Would you state your name, occupation and business address?

A: My name is Paul L. Chernick. I am President of PLC, Inc., 10 Post Office Square, Suite 950, Boston, Massachusetts. I am appearing in this proceeding as an expert witness on behalf of the Attorney General and the State Rating Bureau.

Q: Mr. Chernick, would you please briefly summarize your professional education and experience?

A: I received a S.B. degree from the Massachusetts Institute of Technology in June, 1974 from the Civil Engineering Department, and a S.M. degree from the Massachusetts Institute of Technology in February, 1978 in Technology and Policy. I have been elected to membership in the civil engineering honorary society Chi Epsilon, and the engineering honor society Tau Beta Pi, and to associate membership in the research honorary society Sigma Xi.

I was a Rate Analyst for the Massachusetts Attorney General for over three years, and was involved in numerous aspects of utility rate design, costing, forecasting, and evaluation.

As a Research Associate at Analysis and Inference, and in my current position, I have advised a variety of clients on utility and insurance matters. My resume is attached to this testimony as Exhibit PLC-1.

Q: Mr. Chernick, have you testified previously in regulatory proceedings?

A: Yes. I have testified approximately forty times on utility issues before various agencies including the Massachusetts Department of Public Utilities, the Massachusetts Energy Facilities Sating Council, the Illinois Commerce Commission, the Texas Public Utilities Commission, the New Mexico Public Service Commission, the District of Columbia Public Service Commission, the New Hampshire Public Utilities Commission, the Connecticut Department of Public Utility Control, the Michigan Public Service Commission, the Maine Public Utilities Commission, the Vermont Public Service Board, the Pennsylvania Public Utilities Commission, the Federal Energy Regulatory Commission, and the Atomic Safety and Licensing Board of the U.S. Nuclear Regulatory Commission. A detailed list of my previous testimony is contained in my resume.

Q: Have you testified previously in insurance proceedings before this Division?

A: Yes. I have testified on profit issues in the last five Automobile ratesetting proceedings, for 1983, 1984, 1985, 1986, and 1987 rates. I also testified on profit provisions in the 1987 Workers' Compensation rate case.

Q: Have you authored any publications?

A: Yes. I have authored a number of publications on regulatory policy issues. These are listed in my resume.

Q: What is the purpose of your testimony?

A: I am sponsoring the proposed profit provisions of the Attorney General and State Rating Bureau, subject to the outcome of continuing settlement negotiations.

Q: What is the basis for your recommendation?

A: On the assumption that the parties are close to signing a stipulation on most profit modeling issues, I have computed required profit margins using the Commissioner's Decision model, updated for more recent interest rates and portfolio composition data. The assumptions, modeling and results conform to those used by the Commissioner in fixing and establishing prior rates. They are very similar to those contained in MARB's 1988 Profits Filing Section IV. My implementation differs from MARB's in two respects: I use a lower unearned premium reserve, and a lower

investment income tax rate. If the Stipulation is not executed and approved, I would supplement the recommendations in this filing to include certain proposed improvements to the Commissioner's Decision model which would tend to produce lower profit margin allowances than I have calculated here.

Q: Why do you use a lower unearned premium reserve than does MARB?

A: MARB and I differ in three ways in the derivation of the unearned premium reserves (UPR). First, MARB includes the recovery of the tax on 1986 year-end UPR, which is a windfall loss attributable to a previous year's events. The cost of the 1986 tax (which is spread out over 1987-92) is independent of the level of business a company does in 1986, and even whether it writes policies at all. MARB's estimates of the level of the reserves per dollar of premium for 1988 are

	TOTAL	1988 UPR	1986 UPR
BI & PDL:	.019261	.010418	.008843
PD:	.019861	.011255	.008607

Thus, roughly 45% of the UPR estimate is due to this retroactive recovery.

Second, MARB assumes that the average effective date of policies in 1988 will be much later than suggested by the historical data it provides. As the pre-1978 policies with their January effective dates are gradually replaced by new policies with randomly (approximately evenly) distributed start dates, the average effective date has moved from early February in 1978 to late April in 1986 (1988 MARB (Profits) Section XII-2, page 666). However, as the average effective date moves closer to the middle of the year, new policies have less effect on the average date, and the differences between adjacent years should decrease. In fact, the ratio of one year's average date to the previous year's average date has decreased every year since 1979 (when our data starts). The difference between those two dates has also decreased steadily. Nonetheless, MARB assumes that the trend will accelerate in 1987 and 1988, producing much larger UPR's than would be expected under a continuation of the historical trend. While MARB proposes an average effective date (months past 1/1) of 4.16 in 1987 and 4.39 in 1988, the data supports a much smaller number. Dr. Chang has derived projections of 4.010 for 1987 and 4.078 for 1988. (See 1988 AG Exhibit 100C-9,

p. 1). As fractions of the year, the trended effective dates translate to .3342 and .3398. Substituting these values into equation 8 on page 668 of the MARB Profits filing (and using MARB's assumed premium growth rates) produces 1988 UPR's of .007196 for BI/PDL and .008014 for PD. These are less than half the totals for MARB's UPRs.

Third, MARB assumes that the UPR will be paid in the first quarter. In fact, the UPR is paid on April 15 of the next calendar year. Since UPR is due to growth, it will not be covered by estimated taxes, and will therefore be paid in the reconciliation at the time the tax return is filed. Assuming the same effective date used in the previous calculation, the UPR will be paid after the middle of the fourth quarter of the policy year, for the average policy. I model this payment pattern by placing roughly half of the UPR in the third quarter and the remainder in the fourth quarter.

Roughly speaking, these changes in the MARB's treatment of UPR decreases the required profit margin by 0.5% to 0.7%, with the larger decrease experienced for BI.

Q: Why do you use a different tax rate than does MARB?

A: MARB computes an average investment tax rate of 25.9% for 1988. I have four differences with the MARB's calculation. First, MARB assumes that insurers will pay proration on the economic pre-tax income on tax-exempts, prior to the reduction of that income for the implicit tax effect. In fact, the IRS will not impute the additional "pre-implicit-tax" interest, and will calculate interest only on the interest actually received.

Second, MARB assumes that the pre-tax law implicit tax rate was 28%. For 1985 and pre-TRA 1986 (through July), the average implict tax rate on a monthly basis was only about 25%: only two of the 19 months were over 27%, and only three others were above 26%. The three-month period used in the AG/SRB 1986 filing showed an average of about 27%, which happened to be the highest three-month average in the period.

Third, MARB assumes that the change in the implicit tax rate from 1985/86 to 1988 will be proportional to the change in the marginal tax rate of non-insurance corporations. Individuals will see a larger drop in marginal rates, and insurers would be expected to decrease the market value of the tax exemption to reflect proration, as the Industry Bureau argued in the Workers Comp rate

case. Either of these groups (each of whom who is a major component of the tax-exempt market) would cause larger drops in the tax exempt implicit tax rate than that assumed by MARB.

Fourth, MARB assumes that all stocks and bonds are new, and hence subject to proration. A very small portion of bonds, and a slightly larger fraction of stocks, would have been replaced between 8/8/86 and mid-1988, for our model insurer which trades passively and which has an 11% turnover rate. Thus, proration has a very small effect on 1988 tax rates for the model insurer.

The results of changing these items are shown in Exhibit 9. The effective investment tax rate is thus 22.4%, rather than MARB's 25.9%. The rate result of this change is to lower MARB's estimated required margins by roughly 0.5%.

Q: Could you explain the format of the Exhibits which contain your recommendations?

A: The format follows the pattern used in prior filings. Exhibit 1 contains the necessary definitions. Exhibits 2 through 9 derive the input values for the profit margin calculations. The profit margin calculations are shown separately for each coverage and appear in Exhibit 10. The

calculated Bodily Injury profit margin is -12.64% (1988 AG/SRB, 100H, Exhibit 10, p. 3). The calculated Property Damage Liability profit margin is -3.98%. (1988 AG/SRB, 100H, Exhibit 10, p. 8). The calculated Physical Damage margin is -2.20%. (1988 AG/SRB, 100H, Exhibit 10, p. 13).

Signed under the pains and penalties of perjury this 2nd day of September, 1987

Paul Chernick

Paul Chernick

1988-AG/SRB
100H
Exhibit 1

Discounting and Proportionality of Cash Flows

Type of Cash Flow X (quarter i) (1)	Discount Rate to Discount [X] to Present Value at End of Quarter 0 (2)	Cash flow stream vari proportionally with (3)
LN(i)	RLQ through quarter i RTQ quarter i+1 through N	LN
UTL(i)	RLQ through quarter i RTQ quarter i+1 through N	LN
PTAX(i)	RLQ through quarter i RTQ quarter i+1 through N	P
P(i)	RFQ through quarter i RTQ quarter i+1 through N	P
UTP(i)	RFQ through quarter i RTQ quarter i+1 through N	P
SRP(i)	RFQ	LN

(1) Cash Flow Name

(2) All discounting of cash flows is done at one of 3 quarte discount rates. Discounting of all non-surplus flows occurs after compounding the flow at the after tax investment return (GQ) to its terminal value at Quarter

(3) Each type of cash flow is originally scaled independentl (so that the sum of that type flow=$1000). Yet both in real life, and in the model, the flows are actually dependent on either the total losses (LN) or the total premiums.

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Exhibit 2A

Calculation of Spot Yields

1 Year Treasuries

1 Year Spot
Yield: 6.21% *

Bond Yield: 6.11%

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted PV Cash Flow	(years) True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.50	$3.06	5.91%	0.972	2.97		1.484	
1.00	$103.06	6.21%	0.942	97.03	$100.00	97.029	0.985

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Exhibit 2B

Calculation of Spot Yields

2 Year Treasuries

Bond Yield: 6.60%

2 Year Spot
Yield: 6.73% *

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted PV Cash Flow	(years) True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.50	$3.30	5.91%	0.972	3.20660		1.603	
1.00	$3.30	6.21%	0.942	3.10705		3.107	
1.5	$3.30	6.47%	0.910	3.00381		4.506	
2	$103.30	6.73%	0.878	90.68330	$100.00	181.367	1.906

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Exhibit 2C

Calculation of Spot Yields

3 Year Treasuries

Bond Yield: 6.81%

3 Year Spot
Yield: 6.96% *

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted PV Cash Flow	(years) True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.50	$3.41	5.91%	0.972	3.30863		1.654	
1.00	$3.41	6.21%	0.942	3.20591		3.206	
1.5	$3.41	6.47%	0.910	3.09939		4.649	
2	$3.41	6.73%	0.878	2.98913		5.978	
2.5	$3.41	6.84%	0.848	2.88574		7.214	
3	$103.41	6.96%	0.817	84.51587	$100.00	253.548	2.762

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Exhibit 2D

Calculation of Spot Yields

5 Year Treasuries

Bond Yield: 7.06%

5 Year Spot
Yield: 7.24% *

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted PV Cash Flow	(years) True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.50	$3.53	5.91%	0.972	3.43010		1.715	
1.00	$3.53	6.21%	0.942	3.32360		3.324	
1.5	$3.53	6.47%	0.910	3.21317		4.820	
2	$3.53	6.73%	0.878	3.09886		6.198	
2.5	$3.53	6.84%	0.848	2.99168		7.479	
3	$3.53	6.96%	0.817	2.88517		8.656	
3.5	$3.53	7.03%	0.788	2.78338		9.742	
4	$3.53	7.10%	0.760	2.68343		10.734	
4.5	$3.53	7.17%	0.732	2.58537		11.634	
5	$103.53	7.24%	0.705	73.00678	$100.00	365.034	4.293

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Exhibit 2E

Calculation of Spot Yields

7 Year Treasuries , Year Spot
Yield: 7.55% *
Bond Yield: 7.32%

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted (years) PV Cash Flow	True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.50	$3.66	5.91%	0.972	3.55642		1.778	
1.00	$3.66	6.21%	0.942	3.44600		3.446	
1.5	$3.66	6.47%	0.910	3.33150		4.997	
2	$3.66	6.73%	0.878	3.21298		6.426	
2.5	$3.66	6.84%	0.848	3.10185		7.755	
3	$3.66	6.96%	0.817	2.99142		8.974	
3.5	$3.66	7.03%	0.788	2.88589		10.101	
4	$3.66	7.10%	0.760	2.78225		11.129	
4.5	$3.66	7.17%	0.732	2.68058		12.063	
5	$3.66	7.24%	0.705	2.58094		12.905	
5.5	$3.66	7.31%	0.678	2.48227		13.652	
6	$3.66	7.39%	0.652	2.38562		14.314	
6.5	$3.66	7.47%	0.626	2.29105		14.892	
7	$103.66	7.55%	0.601	62:27042	$100.00	435.893	5.583

Calculation of Spot Yields

10 Year Treasuries

Bond Yield: 7.48%

10 Year Spot Yield: 7.75% *

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted PV Cash Flow	(years) True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.50	$3.74	5.91%	0.972	3.63415		1.817	
1.00	$3.74	6.21%	0.942	3.52133		3.521	
1.5	$3.74	6.47%	0.910	3.40432		5.106	
2	$3.74	6.73%	0.878	3.28321		6.566	
2.5	$3.74	6.84%	0.848	3.16965		7.924	
3	$3.74	6.96%	0.817	3.05681		9.170	
3.5	$3.74	7.03%	0.788	2.94897		10.321	
4	$3.74	7.10%	0.760	2.84306		11.372	
4.5	$3.74	7.17%	0.732	2.73917		12.326	
5	$3.74	7.24%	0.705	2.63735		13.187	
5.5	$3.74	7.31%	0.678	2.53653		13.951	
6	$3.74	7.39%	0.652	2.43776		14.627	
6.5	$3.74	7.47%	0.626	2.34113		15.217	
7	$3.74	7.55%	0.601	2.24668		15.727	
7.5	$3.74	7.58%	0.578	2.16149		16.211	
8	$3.74	7.62%	0.556	2.07891		16.631	
8.5	$3.74	7.65%	0.534	1.99888		16.990	
9	$3.74	7.68%	0.514	1.92136		17.292	
9.5	$3.74	7.71%	0.494	1.84629		17.540	
10	$103.74	7.75%	0.474	49.19655	$100.00	491.966	7.17

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Exhibit 26

Calculation of Spot Yields

20 Year Treasuries

Bond Yield: 7.57%

20 Year Spot
Yield: 7.84% *

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted PV Cash Flow	(years) True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
10.5	$3.79	7.75%	0.457	1.72847		18.149	
11	$3.79	7.76%	0.440	1.66437		18.308	
11.5	$3.79	7.76%	0.423	1.60258		18.430	
12	$3.79	7.76%	0.408	1.54302		18.516	
12.5	$3.79	7.77%	0.392	1.48561		18.570	
13	$3.79	7.77%	0.378	1.43028		18.594	
13.5	$3.79	7.78%	0.364	1.37695		18.589	
14	$3.79	7.78%	0.350	1.32555		18.558	
14.5	$3.79	7.79%	0.337	1.27602		18.502	
15	$3.79	7.79%	0.325	1.22828		18.424	
15.5	$3.79	7.80%	0.312	1.18228		18.325	
16	$3.79	7.80%	0.301	1.13796		18.207	
16.5	$3.79	7.81%	0.289	1.09525		18.072	
17	$3.79	7.81%	0.278	1.05410		17.920	
17.5	$3.79	7.81%	0.268	1.01446		17.753	
18	$3.79	7.82%	0.258	0.97626		17.573	
18.5	$3.79	7.82%	0.248	0.93946		17.380	
19	$3.79	7.83%	0.239	0.90401		17.176	
19.5	$3.79	7.83%	0.230	0.86986		16.962	
20	$103.79	7.84%	0.221	22.94979	$100.00	458.996	10.4916

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Exhibit 2H

Calculation of Spot Yields

30 Year Treasuries

Bond Yield: 7.66%

30 Year Spot
Yield: 8.05% *

Year	Bond's Cash Flow	Annualzd Spot Yield	Discount Factor	Present Value Cash Flow	Sum	Weighted PV Cash Flow	(years) True Duration
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
20.5	$3.83	7.85%	0.213	0.813900		16.685	
21	$3.83	7.86%	0.204	0.782090		16.424	
21.5	$3.83	7.87%	0.196	0.751448		16.156	
22	$3.83	7.88%	0.188	0.721935		15.883	
22.5	$3.83	7.89%	0.181	0.693512		15.604	
23	$3.83	7.90%	0.174	0.666141		15.321	
23.5	$3.83	7.91%	0.167	0.639788		15.035	
24	$3.83	7.92%	0.160	0.614416		14.746	
24.5	$3.83	7.93%	0.154	0.589991		14.455	
25	$3.83	7.94%	0.148	0.566481		14.162	
25.5	$3.83	7.96%	0.142	0.543854		13.868	
26	$3.83	7.97%	0.136	0.522079		13.574	
26.5	$3.83	7.98%	0.131	0.501126		13.280	
27	$3.83	7.99%	0.126	0.480966		12.986	
27.5	$3.83	8.00%	0.121	0.461571		12.693	
28	$3.83	8.01%	0.116	0.442914		12.402	
28.5	$3.83	8.02%	0.111	0.424970		12.112	
29	$3.83	8.03%	0.106	0.407712		11.824	
29.5	$3.83	8.04%	0.102	0.391115		11.538	
30	$103.83	8.05%	0.098	10.17041	$100.00	305.112	11.8798

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Exhibit 3-1

Analysis of Spot Yield Curve:
Components of the Term Structure

Year	Discount Factor	Annualzd Spot Yield	Annualzd Forward Rate	Liquidity Premium Ratio	Annualzd Expected 3-Month Spot Rate
(1)	(2)	(3)	(4)	(5)	(6)
0.25	0.986	5.74%	5.74%	1.0000	5.74%
0.50	0.972	5.91%	6.08%	1.0006	6.02%
0.75	0.957	6.06%	6.36%	1.0011	6.25%
1.00	0.942	6.21%	6.66%	1.0015	6.50%
1.25	0.926	6.34%	6.86%	1.0018	6.66%
1.50	0.910	6.47%	7.12%	1.0022	6.89%
1.75	0.894	6.60%	7.38%	1.0024	7.12%
2.00	0.878	6.73%	7.64%	1.0027	7.36%
2.25	0.863	6.79%	7.24%	1.0029	6.92%
2.50	0.848	6.84%	7.35%	1.0031	7.01%
2.75	0.832	6.90%	7.46%	1.0033	7.11%
3.00	0.817	6.96%	7.58%	1.0035	7.20%
3.25	0.803	6.99%	7.41%	1.0037	7.02%
3.50	0.788	7.03%	7.48%	1.0039	7.07%
3.75	0.774	7.06%	7.55%	1.0040	7.12%
4.00	0.760	7.10%	7.62%	1.0042	7.18%
4.25	0.746	7.13%	7.69%	1.0043	7.23%
4.50	0.732	7.17%	7.76%	1.0044	7.29%
4.75	0.719	7.20%	7.84%	1.0045	7.35%
5.00	0.705	7.24%	7.91%	1.0047	7.40%
5.25	0.692	7.28%	8.07%	1.0048	7.55%
5.50	0.678	7.31%	8.15%	1.0049	7.62%
5.75	0.665	7.35%	8.23%	1.0050	7.69%
6.00	0.652	7.39%	8.31%	1.0051	7.76%
6.25	0.639	7.43%	8.39%	1.0052	7.83%
6.50	0.626	7.47%	8.47%	1.0053	7.90%
6.75	0.613	7.51%	8.54%	1.0054	7.96%
7.00	0.601	7.55%	8.62%	1.0055	8.03%
7.25	0.589	7.57%	8.02%	1.0055	7.43%
7.50	0.578	7.58%	8.05%	1.0056	7.45%
7.75	0.567	7.60%	8.09%	1.0057	7.47%
8.00	0.556	7.62%	8.12%	1.0058	7.50%
8.25	0.545	7.63%	8.15%	1.0059	7.52%
8.50	0.534	7.65%	8.18%	1.0059	7.55%
8.75	0.524	7.67%	8.22%	1.0060	7.57%
		7.68%			

(1) Definition: n Time in years from present.

(2) Definition: dn The discount factor that applies the spot yield in (3) to a cash flow occurring at n in (1), to discount it back to present value at n=0.

Source: (2) = 1 / [1 + Col.(3)]^Col.(1).

(3) Definition: Sn The current Annualized Spot Yield for each n. This yield, as described in the text, is multiperiod, applying to all periods between 0 and n for a cash flow occurring at time n.

Source: For years divisible by .50 (n=.50,1.00,1.50,etc.), yields are taken directly from Exhibit 2F. "Odd" quarters (n=.25, .75, etc.) are interpolated.

(4) Definition: Fn The Annualized Forward Rate for the quarter ending at time n. Derived directly from the term structure.

Source: (4) = {[(2) this period] / [(2) previous period]}^4 - 1

(5) Definition: Qn The Liquidity Premium Ratio accounts for that portion of the Annualized Forward Rate in (4) which is inherent in the term structure to reward holding period risk.

Source: (5) = [0.75 + Col.(1)]^(1 / 376).

(6) Definition: En The Annualized Expected 3-Month Spot Rate is the expected future rate on a 3-month T-bill that starts at n-.25 and matures at n. It is the current estimate of the "short rate" for the quarter ending at time n.

Source: (6) = {[1 + Col.(4)]/Col.(5)} - 1.

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Exhibit 4-1

Column Heading Description
for Weighting of Risk-Free
Rate by Cash Flows, by Line

Period	Year	Annualzd Spot Yield	LN Cash Flow	P Cash Flow	Total Cash Flow	Discount-ing Time	Weight	Spot Yield x Weight
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

(1) Definition: t The period number, by quarters, within which cash flows may occur in the model.

(2) Definition: n Time that the period ends, in years. For example, year 1.00 corresponds to the end of Quarter 4.

(3) Definition: Sn The yield that would exist on a zero bond which matures at time n. This yield is used to discount any cash flows occurring during period t.

Source Exhibit 3, Column 3.

(4) Definition: LN in this quarter per $1000 total LN.

Source: See (5) Source, below (normalized to $1000).

(5) Definition: P in this quarter per $1000 total LN, scaled by P/LN from the Commissioner's 1987 Decision profit margin (MARKUP1 from Table V of Source).

Source Profit margins and cash flows from the Commissioner's Decision on 1987 Rates.

(6) Definition: The absolute sum of LN Cash Flow and P Cash Flow.

Source(6)=|(4)|+|(5)|

(7) Definition: n-1/8 Years from middle of this quarter to end of quarter zero. Since cash flows occur at mid-quarter, discounting occurs over n-1/8, and not n, years.

Source: (7)=(2)-.125

(8) Definition: Total cash flow multiplied by discounting time. This is the weight that will be used to weight the Annualized Spot Yields.

Source: (8)=(6)x(7)

(9) Definition: Annualized Spot Yield weighted by discounted cash flow.

Source: (9)=(8)x(3)

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Exhibit 4A

Weighting of Risk-Free Rate
by Bodily Injury Cash Flows

Period	Year	Annualzd Spot Yield	LN Cash Flow	P Cash Flow	Total Cash Flow		Discounting Time		Weight	Spot Yield x Weight
(1)	(2)	(3)	(4)	(5)	(6)		(7)		(8)	(9)
0	0	5.74%	8.7	76.60	85.315	x	0.125	=	10.664	0.612
1	0.25	5.74%	73.6	394.71	468.293	x	0.125	=	58.537	3.360
2	0.50	5.91%	69.9	250.46	320.365	x	0.375	=	120.137	7.100
3	0.75	6.06%	70.0	121.01	191.013	x	0.625	=	119.383	7.235
4	1.00	6.21%	80.9	30.64	111.516	x	0.875	=	97.577	6.060
5	1.25	6.34%	64.4	2.00	66.385	x	1.125	=	74.683	4.735
6	1.50	6.47%	72.3		72.311	x	1.375	=	99.428	6.433
7	1.75	6.60%	63.3		63.257	x	1.625	=	102.792	6.784
8	2.00	6.73%	67.7		67.651	x	1.875	=	126.845	8.537
9	2.25	6.79%	55.2		55.174	x	2.125	=	117.244	7.956
10	2.50	6.84%	52.0		52.001	x	2.375	=	123.502	8.451
11	2.75	6.90%	38.7		38.731	x	2.625	=	101.668	7.014
12	3.00	6.96%	37.2		37.219	x	2.875	=	107.004	7.442
13	3.25	6.99%	33.9		33.882	x	3.125	=	105.882	7.401
14	3.50	7.03%	31.0		31.048	x	3.375	=	104.787	7.362
15	3.75	7.06%	20.9		20.859	x	3.625	=	75.613	5.339
16	4.00	7.10%	22.1		22.094	x	3.875	=	85.615	6.075
17	4.25	7.13%	16.3		16.258	x	4.125	=	67.064	4.782
18	4.50	7.17%	16.4		16.396	x	4.375	=	71.733	5.140
19	4.75	7.20%	11.9		11.938	x	4.625	=	55.211	3.976
20	5.00	7.24%	13.5		13.488	x	4.875	=	65.755	4.758
21	5.25	7.28%	12.4		12.361	x	5.125	=	63.352	4.609
22	5.50	7.31%	12.8		12.847	x	5.375	=	69.055	5.051
23	5.75	7.35%	6.9		6.865	x	5.625	=	38.615	2.840
24	6.00	7.39%	8.1		8.050	x	5.875	=	47.295	3.497
25	6.25	7.43%	8.9		8.893	x	6.125	=	54.467	4.049
26	6.50	7.47%	6.6		6.625	x	6.375	=	42.237	3.156
27	6.75	7.51%	4.6		4.564	x	6.625	=	30.236	2.271
28	7.00	7.55%	5.0		5.036	x	6.875	=	34.621	2.615
29	7.25	7.57%	4.8		4.797	x	7.125	=	34.181	2.587
30	7.50	7.58%	3.5		3.454	x	7.375	=	25.477	1.932
31	7.75	7.60%	3.2		3.242	x	7.625	=	24.717	1.879
32	8.00	7.62%	3.5		3.486	x	7.875	=	27.454	2.091
Sum:			1000.000	875.416 *					2382.828	163.128

Weighted BI RF Rate: 6.85%
** ------

* The profit margin used here is:
(P/LN=0.875416)

** One weighted rate, RF, is needed for each line. For this line, RF is the Annualized Spot Yields in (3) weighted by the weights in (8). The final result is: RF= Sum(Column 8) / Sum (Column 9).

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Exhibit 4B

Weighting of Risk-Free Rate
by Property Damage Liability Cash Flows

Period	Year	Spot Yield	LN Cash Flow	P Cash Flow	Total Cash Flow		Discounting Time		Weight	Spot Yield x Weight
(1)	(2)	(3)	(4)	(5)	(6)		(7)		(8)	(9)
0	0	5.74%	19.5	85.52	105.009	x	0.125	=	13.126	0.753
1	0.25	5.74%	167.9	440.70	608.623	x	0.125	=	76.078	4.367
2	0.50	5.91%	194.4	279.64	474.071	x	0.375	=	177.777	10.507
3	0.75	6.06%	183.2	135.11	318.341	x	0.625	=	198.963	12.057
4	1.00	6.21%	173.6	34.21	207.805	x	0.875	=	181.829	11.292
5	1.25	6.34%	117.0	2.23	119.250	x	1.125	=	134.157	8.506
6	1.50	6.47%	55.6		55.606	x	1.375	=	76.458	4.947
7	1.75	6.60%	27.9		27.855	x	1.625	=	45.264	2.987
8	2.00	6.73%	17.9		17.927	x	1.875	=	33.614	2.262
9	2.25	6.79%	11.0		10.959	x	2.125	=	23.288	1.580
10	2.50	6.84%	11.1		11.127	x	2.375	=	26.426	1.808
11	2.75	6.90%	5.9		5.897	x	2.625	=	15.479	1.068
12	3.00	6.96%	4.0		3.978	x	2.875	=	11.438	0.796
13	3.25	6.99%	2.5		2.529	x	3.125	=	7.904	0.552
14	3.50	7.03%	2.4		2.445	x	3.375	=	8.253	0.580
15	3.75	7.06%	2.0		2.017	x	3.625	=	7.313	0.516
16	4.00	7.10%	1.3		1.301	x	3.875	=	5.041	0.358
17	4.25	7.13%	0.7		0.728	x	4.125	=	3.002	0.214
18	4.50	7.17%	0.5		0.549	x	4.375	=	2.400	0.172
19	4.75	7.20%	1.0		1.049	x	4.625	=	4.852	0.349
20	5.00	7.24%	0.3		0.344	x	4.875	=	1.677	0.121
Sum:			1000	977.412 *					1054.337	65.793

Weighted PDL RF Rate: 6.24% **

* The profit margin used here is:
(P/LN=0.977412)

** One weighted rate, RF, is needed for each line. For this line, RF is the Annualized Spot Yields in (3) weighted by the weights in (8). The final result is: RF= Sum(Column 8) / Sum (Column 9).

1988-AG/SRB
100H
Exhibit 4C

Weighting of Risk-Free Rate by Physical Damage Cash Flows

Period	Year	Annualzd Spot Yield	LN Cash Flow	P Cash Flow	Total Cash Flow		Discounting Time		Weight	Spot Yield x Weight
(1)	(2)	(3)	(4)	(5)	(6)		(7)		(8)	(9)
0	0	5.74%	12.6	84.59	97.222	x	0.125	=	12.153	0.698
1	0.25	5.74%	207.6	435.89	643.488	x	0.125	=	80.436	4.617
2	0.50	5.91%	263.4	276.59	539.982	x	0.375	=	202.493	11.967
3	0.75	6.06%	234.4	133.64	368.049	x	0.625	=	230.031	13.940
4	1.00	6.21%	226.0	33.84	259.837	x	0.875	=	227.357	14.119
5	1.25	6.34%	104.9	2.21	107.140	x	1.125	=	120.533	7.642
6	1.50	6.47%	-12.7		12.739	x	1.375	=	17.516	1.133
7	1.75	6.60%	-9.7		9.669	x	1.625	=	15.713	1.037
8	2.00	6.73%	-8.6		8.632	x	1.875	=	16.184	1.089
9	2.25	6.79%	-4.9		4.915	x	2.125	=	10.444	0.709
10	2.50	6.84%	-3.4		3.411	x	2.375	=	8.102	0.554
11	2.75	6.90%	-3.0		2.972	x	2.625	=	7.802	0.538
12	3.00	6.96%	-1.9		1.886	x	2.875	=	5.423	0.377
13	3.25	6.99%	-1.3		1.330	x	3.125	=	4.155	0.290
14	3.50	7.03%	-1.0		1.000	x	3.375	=	3.375	0.237
15	3.75	7.06%	-0.8		0.797	x	3.625	=	2.890	0.204
16	4.00	7.10%	-0.5		0.531	x	3.875	=	2.058	0.146
17	4.25	7.13%	-0.6		0.646	x	4.125	=	2.664	0.190
18	4.50	7.17%	-0.1		0.138	x	4.375	=	0.605	0.043
19	4.75	7.20%	-0.2		0.166	x	4.625	=	0.767	0.055
20	5.00	7.24%	-0.1		0.137	x	4.875	=	0.669	0.048
Sum:			1000	966.75					971.371	59.635

Weighted PD RF Rate: 6.14%

* The profit margin used here is:
(P/LN= 0.96675)

** One weighted rate, RF, is needed for each line. For this line, RF is the Annualized Spot Yields in (3) weighted by the weights in (8). The final result is: RF= Sum (Column 8) / Sum (Column 9).

Calculation of Liquidity Premium on Portfolio (LPP)

Categories	Portfolio %	Liquidity Premium
(1)	(2)	(3)
U.S. Government Bonds	22.0%	0.38%
Other Taxable Bonds	20.5%	0.38%
Tax-Exempt Bonds	33.0%	0.58%
Stocks	22.8%	0
Other Assets	1.7%	0
Total	100%	0.35%

LPP is the weighted average liquidity premium for the entire Realistic Insurer Portfolio. Calculated as:

LPP=Sum[Column(2) x Column (3)].

(1) Definition: Categories of investments in the Realistic Insurer Portfolio.

(2) Definition: Percent of portfolio invested in the particular category of assets.

Source: Flow of funds data, from MARB, 1988 Draft Stipulation, 8/4/87

(3) Definition: LPt is the liquidity premium on each category of assets, as held in the Realistic Insurer Portfolio above. Includes LPP and LPE.

Source: Liquidity Premia calculated in 1988-AG/SRB, 100H, Exhibit 5A (next page).

1988-AG/SRB
100H
Exhibit 5A

Weighting of Portfolio Duration to Estimate Liquidity Premium (1)

Bond Maturity	Average of	Duration	Liquidity Premium	($ 000,000) Taxable Bonds	Tax-exempt Bonds	
(1)	(2)	(3)	(4)	(5)	(6)	
<= 1 year	6 mo	0.50	0.06%	5141	199	3.0846
						0
1 - 3 yrs.	1 yr					0
	2 yr	1.88	0.26%	3007	734	7.8182
	3 yr					0
3 - 5 yrs.	3 yr	3.53	0.38%	2960	759	11.248
	5 yr					0
5 - 10 yrs.	5 yr					0
	7 yr	5.68	0.49%	5455	2962	26.7295
	10 yr					0
10 - 15 yrs.	10 yr x .75	8.00	0.57%	1128	4600	6.4296
	20 yr x .25					0
15 - 20 yrs.	10 yr x .25	9.66	0.61%	1136	6132	6.9296
	20 yr x .75					0
> 20 yrs.	20 yr	11.19	0.65%	3117	10030	20.2605
	30 yr					
Total				21944	25416	82.5
Weighted Average (7)				(8)	(9)	
Liquidity Premium				0.38%	0.58%	

(1) Definition: Category of Bond Maturity held in the Realistic Insurer Portfolio.

Source: Maturity Distribution of Bonds--Summary (1986 MARB, 100H-3, Page 4).

(2) Definition: Bond maturities for which the durations are averaged, in Column (3).

Source: Treasury maturities for which we have durations (see Exhibit 5B, next page), and which are representative of the assets found in the category of bond maturity in (1), are used to find an average duration for each category (row) of asset maturities.

(3) Definition: Average duration of the instruments shown in Column (2), for each maturity category.

Source: 1988-AG/SRB, 100H, Exhibit 5B, averaging durations for only those bonds shown in Column (2).

(4) Definition: LPn The Liquidity Premium portion of the expected annualized holding period return for a portfolio that holds bonds with the duration listed in Column (3) for one quarter.

Source: Using (3) above as the "Year," go to Exhibit 3 herein, Column (1). Interpolated value from Exhibit 3, Column (5), minus one, is used in this exhibit's Column (4) above.

(5) Definition: Millions of dollars of taxable bonds held by MARB's Sample Company Group in 1984, divided (by rows) into groups by bond maturity.

Source: Maturity Distribution of Bonds -- Summary (1986 MARB Filing, 100H-3, page 4, Rows 1 and 2).

(6) Same as (5), except for tax-exempt bonds.

(7) This table uses the Maturity Distribution of Bonds--Summary (1986 MARB, 100H-3, Page 4) to weight the liquidity premia for the relevant maturities, from a spot yield curve developed from 12-Month Average Yield Rates (MARB 1988 Draft Stipulation, 8/4/87). This weighted rate reflects the liquidity premium of each category of bond in insurers' portfolios.

(8) LPT, Liquidity Premium on Taxable Bond portion of portfolio. Calculated as LPT= Sum [Column (4) x Column (5)]/Sum [Column (5)].

(9) LPE, Liquidity Premium on Exempt Bond portion of portfolio. Calculated as LPE= Sum[Column (4) X Column (6) / Sum[Column (6)].

1988-AG/SRB
100H
Exhibit 5B

Durations of Treasury Securities

Maturity	Duration (yr)
(1)	(2)
Bills: 3 mo	0.250
6 mo	0.500
Notes: 1 yr	0.985
2 yr	1.906
Bonds: 3 yr	2.762
5 yr	4.293
7 yr	5.583
10 yr	7.175
20 yr	10.492
30 yr	11.880

(1) Definition: The maturity of the Treasury instruments needed in the development of Exhibits 2-5, as listed by MARB in the Source (2) below.

(2) Definition: Duration calculations done for each coupon bond in the development of the spot yield curve. Yields based on MARB's 12-month average.

Source: Duration calculations for Notes and Bonds displayed in 1988-AG/SRB, 100H, Exhibits 2A - 2F, Column (8). Yields based on 12-Month Average Yield Rates (MARB 1988 Draft Stipulation, 8/4/87, Attachment D).

1988-AG/SRB
100H
Exhibit 6-1

PRESENT VALUE OF TAX RATE ON CAPITAL GAINS

Year	Realized Capital Gains --[1]--	Taxes Paid --[2]--
1	11.00	3.74
2	9.79	3.33
3	8.71	2.96
4	7.75	2.64
5	6.90	2.35
6	6.14	2.09
7	5.47	1.86
8	4.87	1.65
9	4.33	1.47
10	3.85	1.31
11	3.43	1.17
12	3.05	1.04
13	2.72	0.92
14	2.42	0.82
15	2.15	0.73
16	1.92	0.65
17	1.70	0.58
18	1.52	0.52
19	1.35	0.46
20	1.20	0.41
21	1.07	0.36
22	0.95	0.32
23	0.85	0.29
24	0.75	0.26
25	0.67	0.23
26	0.60	0.20
27	0.53	0.18
28	0.47	0.16
29	0.42	0.14
30	0.37	0.13
31	0.33	0.11
32	0.30	0.10
33	0.26	0.09
34	0.24	0.08
35	0.21	0.07
36	0.19	0.06
37	0.17	0.06
38	0.15	0.05
39	0.13	0.04
40	0.12	0.04
41	0.10	0.04
Total	99.2	33.7
PV at RF	67.1	22.8
PV Tax rate		23.0%

+TURNOVER	+PVTXRT
5%	18%
10%	22%
11%	23%
12%	24%
13%	24%
14%	25%
15%	25%
16%	26%
17%	26%
18%	27%
19%	27%
20%	27%
25%	29%
30%	30%
35%	31%
40%	31%
45%	32%
50%	32%
55%	32%
60%	33%
65%	33%
70%	33%
75%	33%
80%	33%
85%	34%
90%	34%
95%	34%
100%	34%

87EX6A

Exhibit 6 (Continued):

RF =	6.43%	(Risk-free rate)
RM =	15.43%	(Expected Return on Common Stock)
RMCG =	10.43%	(Capital Gains Portion of Return)
TICG =	34%	(Statutory Tax Rate on Capital Gains)
TICG0 =	34%	(First-Year Tax Rate on Capital Gains)
Turnover =	11%	(Percent of Capital Gains Taken Each Year)
CapGain =	$100	(Capital Gain in Year 1)

NOTES: (1) REALIZED CAPITAL GAINS = turnover * (Capital Gains minus the sum of realized capital gains to date.

(2) TAXES PAID is TI * Realized Capital Gains.

1988-AG/SRB
100H
Exhibit 6A

Quarter-by-quarter Investment Returns
for Bodily Injury Line, to
estimate Liquidity Premium in RA

Year	Annualz'd Expected 3-Month Spot Rate	Liquid-ity Premium on Portfolio	Expected Holding Period Return	Weight by BI Investment Balance	Weighted Non-beta Holding Period Return
(1)	(2)	(3)	(4)	(5)	(6)
0.00			6.09%	70.39	
0.25	5.74%	0.35%	6.09%	914.03	
0.50	6.02%	0.35%	6.37%	1118.53	
0.75	6.25%	0.35%	6.60%	1192.92	
1.00	6.50%	0.35%	6.85%	1164.44	
1.25	6.66%	0.35%	7.01%	556.31	
1.50	6.89%	0.35%	7.24%	493.99	
1.75	7.12%	0.35%	7.47%	439.61	
2.00	7.36%	0.35%	7.71%	379.86	
2.25	6.92%	0.35%	7.27%	331.51	
2.50	7.01%	0.35%	7.36%	285.46	
2.75	7.11%	0.35%	7.46%	251.86	
3.00	7.20%	0.35%	7.55%	219.17	
3.25	7.02%	0.35%	7.37%	189.22	
3.50	7.07%	0.35%	7.42%	161.58	
3.75	7.12%	0.35%	7.47%	143.62	
4.00	7.18%	0.35%	7.53%	124.11	
4.25	7.23%	0.35%	7.58%	110.08	
4.50	7.29%	0.35%	7.64%	95.66	
4.75	7.35%	0.35%	7.70%	85.44	
5.00	7.40%	0.35%	7.75%	73.49	
5.25	7.55%	0.35%	7.90%	62.45	
5.50	7.62%	0.35%	7.97%	50.72	
5.75	7.69%	0.35%	8.04%	44.77	
6.00	7.76%	0.35%	8.11%	37.52	
6.25	7.83%	0.35%	8.18%	29.30	
6.50	7.90%	0.35%	8.25%	23.21	
6.75	7.96%	0.35%	8.31%	19.06	
7.00	8.03%	0.35%	8.38%	14.37	
7.25	7.43%	0.35%	7.78%	9.83	
7.50	7.45%	0.35%	7.80%	6.55	
7.75	7.47%	0.35%	7.82%	3.42	
8.00	7.50%	0.35%	7.85%	0.00	6.95%

1988-AG/SRB
100H
Exhibit 6B

Quarter-by-quarter Investment Returns
for Property Damage Liability line,
to estimate Liquidity Premium in RA

Year	Annualz'd Expected 3-Month Spot Rate	Liquidity Premium on Portfolio	Expected Holding Period Return	Weight by PDL Investment Balance	Weighted Non-Beta Holding Period Return
(1)	(2)	(3)	(4)	(5)	(6)
			6.09%	68.84	
0.25	5.74%	0.35%	6.09%	853.13	
0.50	6.02%	0.35%	6.37%	949.49	
0.75	6.25%	0.35%	6.60%	909.45	
1.00	6.50%	0.35%	6.85%	774.16	
1.25	6.66%	0.35%	7.01%	137.09	
1.50	6.89%	0.35%	7.24%	83.86	
1.75	7.12%	0.35%	7.47%	57.45	
2.00	7.36%	0.35%	7.71%	40.52	
2.25	6.92%	0.35%	7.27%	30.27	
2.50	7.01%	0.35%	7.36%	19.66	
2.75	7.11%	0.35%	7.46%	14.11	
3.00	7.20%	0.35%	7.55%	10.37	
3.25	7.02%	0.35%	7.37%	8.02	
3.50	7.07%	0.35%	7.42%	5.72	
3.75	7.12%	0.35%	7.47%	3.80	
4.00	7.18%	0.35%	7.53%	2.56	
4.25	7.23%	0.35%	7.58%	1.88	
4.50	7.29%	0.35%	7.64%	1.36	
4.75	7.35%	0.35%	7.70%	0.34	
5.00	7.40%	0.35%	7.75%	0.00	6.55%

1988-AG/SRB
100H
Exhibit 6C

Quarter-by-quarter Investment Returns
for Physical Damage line, to
estimate Liquidity Premium in RA

Year	Annualz'd Expected 3-Month Spot Rate	Liquid-ity Premium on Portfolio	Expected Holding Period Return	Weight by PD Investment Balance	Weighted Non-beta Holding Period Return
(1)	(2)	(3)	(4)	(5)	(6)
			6.09%	77.44	
0.25	5.74%	0.35%	6.09%	828.84	
0.50	6.02%	0.35%	6.37%	859.13	
0.75	6.25%	0.35%	6.60%	766.70	
1.00	6.50%	0.35%	6.85%	574.83	
1.25	6.66%	0.35%	7.01%	0.00	
1.50	6.89%	0.35%	7.24%	0.00	
1.75	7.12%	0.35%	7.47%	0.00	
2.00	7.36%	0.35%	7.71%	0.00	
2.25	6.92%	0.35%	7.27%	-0.00	
2.50	7.01%	0.35%	7.36%	-0.00	
2.75	7.11%	0.35%	7.46%	-0.00	
3.00	7.20%	0.35%	7.55%	-0.00	
3.25	7.02%	0.35%	7.37%	-0.00	
3.50	7.07%	0.35%	7.42%	-0.00	
3.75	7.12%	0.35%	7.47%	-0.00	
4.00	7.18%	0.35%	7.53%	-0.00	
4.25	7.23%	0.35%	7.58%	-0.00	
4.50	7.29%	0.35%	7.64%	-0.00	
4.75	7.35%	0.35%	7.70%	-0.00	
5.00	7.40%	0.35%	7.75%	-0.00	6.43%

1988-AG/SRB
100H
Exhibit 6A,B,C

Definitions and Sources of Quarter-by-quarter Investment Returns to Estimate Liquidity

Year	Annualz'd Expected 3-month Spot Rate	Liquidity Premium on Portfolio	Expected Holding Period Return	Weight by Investment Balance	Weighted Holding Period Return
(1)	(2)	(3)	(4)	(5)	(6)

(1) Definition: n The period ending at time n, in years.

(2) Definition: En The Annualized Expected 3-Month Spot Rate is the expected future rate on a 3-month T-bill that starts at n-.25 and matures at n. It is the "short rate" for the period ending at time n.

Source: Column (6) of 1988-AG/SRB, 100H, Exhibit 3.

(3) Definition: LPP, the Liquidity Premium on Portfolio, annualized. This is added to the expected holding period returns for the portfolio.

Source:LPP calculated in 1988-AG/SRB, 100H, Exhibit 5

(4) Definition: The annualized rate of return expected for the portfolio for the quarter ending at time n, including the returns due to the reward for beta risk

Source: (4) = (2) + (3)

(5) Definition: Investment balance for each line, by quarter, taken from the Commissioner's 1987 Decision on Auto Insurance Rates.

Source: 1987-AG/SRB, 100H.
1987 Profit Margin Calculations by Line,
Table V, Column (9).

(6) Definition: In addition to that portion of the portfolio return due to reward for beta risk, the return on (RA), includes the non-beta portion of the holding period return. The Weighted Non-beta Holding Period Return for each line is each quarterly return, weighted by the investment balance that applies to that quarter.

When the asset beta is multiplied by the market risk premium and added to the above Weighted Return, the result is the RA (annualized) of the asset portfolio.

Source: The sum of each [(4)x(5)], divided by the sum of Column (5).

1988-AG/SRB
100H
Exhibit 7

Calculation of Beta on Investment Portfolio

Categories	Portfolio %	Beta
(1)	(2)	(3)
U.S. Government Bonds	22.0%	0
Other Taxable Bonds	20.5%	0.04
Tax-Exempt Bonds	33.0%	0.04
Stocks	22.8%	1
Other Assets	1.7%	1.2
Total	100.0%	0.27 (4)

(1) Definition: Categories of investments in the Realistic Insurer Portfolio.

Source: 1986 MARB Filing, 100H-3, Page 1.

(2) Definition: Percent of the portfolio invested in the particular category of investment.

Source: Flow of funds data, Federal Reserve, as of August 1986.

(3) Definition: The market beta of each category of assets, after accounting for the liquidity premium portion of holding period risk. For bonds, that is the beta that accounts for default/market risk only. Beta for bonds is described in the text, and calculated in Exhibit 7A.

Source: Beta for Other Assets is estimated in 1986-AG/SRB, 100H, Exhibit 7B.

(4) BA, the Beta of Assets, is the asset-value-weighted market beta for the Realistic Insurer Portfolio. Calculated as:

BA= Sum[Column (2) x Column (3)].

1988-A6/S RB
100H
Exhibit 8 -1

IMPLICIT TAX RATES ON MUNICIPAL BONDS

January 1985	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	9.15	11.67	12.47	12.08	21.6%	26.6%	24.3%	
Aa	9.54	12.18	12.68	12.43	21.7%	24.8%	23.3%	Comp
A	9.82	12.61	12.99	12.80	22.1%	24.4%	23.3%	Ave.
Baa	10.22	13.15	13.36	13.26	22.3%	23.5%	22.9%	23.4%

February 1985	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.91	11.64	12.61	12.13	23.5%	29.3%	26.5%	
Aa	9.39	12.10	12.87	12.49	22.4%	27.0%	24.8%	Comp
A	9.59	12.51	13.08	12.80	23.3%	26.7%	25.1%	Ave.
Baa	10.00	13.00	13.44	13.23	23.1%	25.6%	24.4%	25.2%

March 1985	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	9.15	12.04	13.08	12.56	24.0%	30.0%	27.1%	
Aa	9.55	12.32	13.50	12.91	22.5%	29.3%	26.0%	Comp
A	9.76	12.84	13.87	13.36	24.0%	29.6%	26.9%	Ave.
Baa	10.16	13.18	14.19	13.69	22.9%	28.4%	25.8%	26.5%

April 1985	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.95	11.67	12.77	12.23	23.3%	29.9%	26.8%	
Aa	9.26	12.22	13.17	12.69	24.2%	29.7%	27.0%	Comp
A	9.55	12.71	13.61	13.14	24.9%	29.8%	27.3%	Ave.
Baa	9.95	12.90	14.11	13.51	22.9%	29.5%	26.4%	26.9%

May 1985	Yields(%)	Implicit Tax Rates Municipals Yield vs:

Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.52	11.26	12.18	11.72	24.3%	30.0%	27.3%	
Aa	8.88	11.95	12.65	12.30	25.7%	29.8%	27.8%	Comp
A	9.14	12.28	13.12	12.70	25.6%	30.3%	28.0%	Ave.
Baa	9.54	12.68	13.62	13.15	24.8%	30.0%	27.5%	27.6%

June 1985 Yields(%) — Implicit Tax Rates Municipals Yield vs:

Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.24	10.71	11.17	10.94	23.1%	26.2%	24.7%	
Aa	8.39	11.24	11.68	11.46	25.4%	28.2%	26.8%	Comp
A	8.60	11.83	12.13	11.98	27.3%	29.1%	28.2%	Ave.
Baa	9.02	12.14	12.66	12.40	25.7%	28.8%	27.3%	26.7%

July 1985 Yields(%) — Implicit Tax Rates Municipals Yield vs:

Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.34	10.74	11.18	10.97	22.3%	25.4%	24.0%	
Aa	8.55	11.29	11.55	11.42	24.3%	26.0%	25.1%	Comp
A	8.76	11.77	12.07	11.92	25.6%	27.4%	26.5%	Ave.
Baa	9.18	12.17	12.70	12.43	24.6%	27.7%	26.1%	25.4%

August 1985 Yields(%) — Implicit Tax Rates Municipals Yield vs:

Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.49	10.86	11.23	11.05	21.8%	24.4%	23.2%	
Aa	8.81	11.29	11.65	11.47	22.0%	24.4%	23.2%	Comp
A	9.11	11.87	12.13	12.00	23.3%	24.9%	24.1%	Ave.
Baa	9.50	12.27	12.73	12.50	22.6%	25.4%	24.0%	23.6%

September 1985 Yields(%) — Implicit Tax Rates Municipals Yield vs:

Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.70	10.87	11.27	11.07	20.0%	22.8%	21.4%	
Aa	9.03	11.24	11.68	11.46	19.7%	22.7%	21.2%	Comp
A	9.33	11.85	12.13	11.99	21.3%	23.1%	22.2%	Ave.
Baa	9.63	12.24	12.72	12.48	21.3%	24.3%	22.8%	21.9%

October 1985 Yields(%) — Implicit Tax Rates Municipals Yield vs:

Rating	Muni.	Ind.	Util.	Comp.	Indust.	Util.	Comp.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Aaa	8.65	10.80	11.23	11.02	19.9%	23.0%	21.5%	
Aa	9.00	11.29	11.61	11.45	20.3%	22.5%	21.4%	Comp
A	9.25	11.85	12.01	11.94	21.9%	23.0%	22.5%	Ave.
Baa	9.59	12.20	12.52	12.36	21.4%	23.4%	22.4%	22.0%

November 1985	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	8.16	10.38	10.71	10.55	21.4%	23.8%	22.7%	
Aa	8.50	11.03	11.10	11.07	22.9%	23.4%	23.2%	Comp
A	8.79	11.58	11.49	11.54	24.1%	23.5%	23.8%	Ave.
Baa	9.23	11.93	12.04	11.99	22.6%	23.3%	23.0%	23.2%

December 1985	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	7.98	10.08	10.24	10.16	20.8%	22.1%	21.5%	
Aa	8.31	10.69	10.57	10.63	22.3%	21.4%	21.8%	Comp
A	8.64	11.39	10.97	11.19	24.1%	21.2%	22.8%	Ave.
Baa	9.05	11.67	11.48	11.58	22.5%	21.2%	21.8%	22.0%

January 1986	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	7.70	9.95	10.14	10.05	22.6%	24.1%	23.4%	
Aa	8.05	10.47	10.44	10.46	23.1%	22.9%	23.0%	Comp
A	8.25	11.27	10.79	11.04	26.8%	23.5%	25.3%	Ave.
Baa	8.79	11.63	11.24	11.44	24.4%	21.8%	23.2%	23.7%

February 1986	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	7.26	9.68	9.65	9.67	25.0%	24.8%	24.9%	
Aa	7.55	10.27	9.98	10.13	26.5%	24.3%	25.5%	Comp
A	7.84	11.07	10.26	10.67	29.2%	23.6%	26.5%	Ave.
Baa	8.30	11.48	10.74	11.11	27.7%	22.7%	25.3%	25.6%

March 1986	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	

Aaa	6.72	9.23	8.75	9.00	27.2%	23.2%	25.3%	
Aa	6.88	9.82	9.16	9.49	29.9%	24.9%	27.5%	Comp
A	7.20	10.81	9.48	10.15	33.4%	24.1%	29.1%	Ave.
Baa	7.58	11.08	9.91	10.50	31.6%	23.5%	27.8%	27.4%

April 1986	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	6.81	9.13	8.45	8.79	25.4%	19.4%	22.5%	
Aa	7.01	9.55	8.87	9.21	26.6%	21.0%	23.9%	Comp
A	7.22	10.51	9.14	9.83	31.3%	21.0%	26.6%	Ave.
Baa	7.45	10.74	9.63	10.19	30.6%	22.6%	26.9%	25.0%

May 1986	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	7.22	9.11	9.07	9.09	20.7%	20.4%	20.6%	
Aa	7.40	9.47	9.38	9.43	21.9%	21.1%	21.5%	Comp
A	7.65	10.28	9.59	9.94	25.6%	20.2%	23.0%	Ave.
Baa	7.84	10.55	10.02	10.29	25.7%	21.8%	23.8%	22.2%

June 1986	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	7.49	9.24	9.02	9.13	18.9%	17.0%	18.0%	
Aa	7.66	9.61	9.36	9.49	20.3%	18.2%	19.3%	Comp
A	7.86	10.29	9.62	9.96	23.6%	18.3%	21.1%	Ave.
Baa	8.14	10.65	10.03	10.34	23.6%	18.8%	21.3%	19.9%

July 1986	Yields(%)				Implicit Tax Rates Municipals Yield vs:			
Rating (1)	Muni. (2)	Ind. (3)	Util. (4)	Comp. (5)	Indust. (6)	Util. (7)	Comp. (8)	
Aaa	7.24	9.09	8.66	8.88	20.4%	16.4%	18.5%	
Aa	7.40	9.51	9.05	9.28	22.2%	18.2%	20.3%	Comp
A	7.68	9.14	9.37	9.76	16.0%	18.0%	21.3%	Ave.
Baa	7.90	10.64	9.69	10.16	25.8%	18.5%	22.2%	20.6%

Overall Average: 24.1%

NOTES:

(1) Definition: Bond rating is a way of classifying bonds according to the risk of the investment.

Source: Moody's Bond Record, June 1987.

(2) Definition: Monthly yields on Municipal Bonds.

Source: "Moody's Municipal Bond Yield Averages" table in Moody's Bond Record, June 1987.

(3) Definition: Monthly yields on Industrial bonds.

Source: "Moody's Corporate Bond Yield Averages" table in Moody's Bond Record, June, 1987.

(4) Definition: Monthly yields on Public Utility bonds.

Source: Same as Column (3).

(5) Definition: Monthly composite yields by ratings.

Source: Same as Column (3). Composite yields came from the columns labeled "Corporate by Ratings."

(6) Definition: The implicit tax rate of municipal bonds as compared only to industrial bonds.

Source: (6)=1-[(2)/(3)]

(7) Definition: The implicit tax rate of municipal bonds as compared only to public utility bonds.

Source: (6)=1-[(2)/(4)]

(8) Defintion: The implicit tax rate of municipal bonds as compared to Moody's Corporate Bond Index.

Source: (8)=1-[(2)/(5)]

Note: Composite is the Moody's overall CORPORATE BOND INDEX as described in Moody's Bond Survey.

Calculation of Tax Rate on Investment Income (TI)
(per $1000 of assets)

Categories	Assets	Expected Rtn. on Assets	Expected Pre-Tax Income	% of Total Income	Tax Rate	Taxes	Real Income	Real Tax Rate	Real Taxes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
U.S. Government Bonds	220	6.81%	14.99	16.27%	34.0%	5.10	14.99	34.0%	5.10
Other Taxable Bonds	205	7.17%	14.70	15.96%	34.0%	5.00	14.70	34.0%	5.00
Tax-Exempt Bonds	330	7.37%	24.33	26.41% 1.895	14.3%	3.49	20.84	0.0%	0.00
Stocks:	228	15.43%							
Dividends	*	4.97%	11.33	12.30%	8.2%	0.93	11.33	8.2%	0.93
Capital Gains		10.46%	23.85	25.89%	23.0%	5.49	23.85	28.0%	6.68
Other Assets	17	17.23%	2.93	3.18%	22.4%	0.66	2.93	22.4%	0.66
Total	1000	9.21%	92.13	289%	22.4% TI	20.65	88.64	20.7%	18.35

(1) Definition: Categories of investments in the Realistic Insurer Portfolio. Income from stocks divided into components.

(2) Definition: Dollars of assets in each category, per $1000 in the entire portfolio.

Source: MARB, 1988.

(3) Definition: Expected rate of return for Assets, by Category.
Return on Assets = RF + LP + Beta*0.09

where risk-free rate, weighted 35/30/35, is

RF = 6.43%;

Source: Values in RF are from exhibit 4A,B,C, by line.
LP comes from 1988-AG/SRB, 100H, Exhibit 5, Col.(3).
Beta comes from 1988-AG/SRB, 100H, Exhibit 7, Column(3).

* Dividend rate is the 10-year (1974-1983) average dividend yield on common stocks from Ibbotson & Sinquefield, op. cit. Remainder of return on stocks is capital gains.

(4) Definition: Expected Pre-Tax Income is the average annual return expected on the category of assets in (2) at rate in (3).

Pre-tax income on Tax Exempt Bonds includes implied income, so that at an implicit 23% tax rate, the post-tax expected income is the expected exempt income.

Source: (4)=(2)x(3)

(5) Definition: The percent of total income on the entire portfolio that is expected to be earned as income on the category of assets listed in (1).

Source: (5)=(4)/[Sum of Column (4)].

(6) Definition: Tax Rate on investment income for each category.

Source: Tax rate for tax exempt bonds =
1 - (1-implicit rate x 28%/50%) x (1-.15 x .34 x (1-(1-.0208)/(1+10.525%^1.895)).
Proration was applied to bonds less than one year, and to the fraction of bonds with 1 - 3 year duration at 8/8/86, which would mature by 6/30/88. The fraction was then adjusted for probable growth in the number of bonds.
Tax rate for dividends =
(1-.8) x .34 + .15 x .8 x .34 x (1-(.89^1.895)/((1 + 10.525%)^1.895).
Proration was applied to fraction of equity new since 8/8/86 at 11% turnover.
Other tax rates are from 1987 tax law.
Tax rate on Other Assets is assumed to be the same as that on the overall portfolio.

(7) Definition: Taxes on the expected income in Column (4) at the rate in Column (6).

Source: (7)=(4)x(6)

(8) Definition Real Income for Tax-Exempt Bonds = (4) - (7).
All other categories have the same value as the Expected Pre-Tax Income.

(9) Definition Real Tax Rate for Tax-Exempt Bonds = 0%.
Real Tax Rate for Capital Gains = 23%.
All other categories are equal to the Tax Rate.

(10) Definition (8) * (9).

I. PARAMETER VALUES

Variable	Formula or Source	Values Annual	Quarterly
MRP		9%	
TI		22.4%	
RF		6.85%	
RFQ	(1+RF)^0.25-1		1.67%
BL		-0.16	
RL	+RF+BL*$MRP	5.4%	
RLQ	(1+RL)^0.25-1		1.33%
BA		0.27	
LPA		0.11%	
RA	+RF+BA*$MRP+LPA	9.4%	
RAQ	(1+RA)^0.25-1		2.27%
RT	+RF+(1-TI)*(BA*MRP+L	8.8%	
RTQ	(1+RT)^0.25-1		2.14%
G	(1-TI)*RA	7.3%	
GQ	(1+G)^0.25-1		1.77%
RATIO	(1+G)/(1+RT)	98.6%	
RATQ	+RATIO^0.25		99.65%
T			5
PAYBEN	(1-RATQ^(N-T))/(1+RF FQ)^(T-.5)	0.085	
TU		34%	
PT		2.3%	
S		2	
RTI		20.7%	
EBU		0.26%	

BODILY INJURY MARGIN CALCULATION 30-Sep-87 1988-AG/SRB 100H Exhibit 10-2

II. CASH FLOWS

+N 32

QUARTER	(1) LN	(2) PV [LN]	(3) P	(4) PV [P]	(5) UTP	(6) PV [UTP]	(7) UTL	(8) PV [UTL]	(9) SRP	(10) PV (SRP)
0	8.7	7.835	90.15	81.13			8.72	7.84		0.00
1	73.6	65.497	464.54	412.69	257.57	228.82	228.86	203.66	250.00	247.94
2	68.7	60.569	294.76	258.48	257.57	225.87	228.86	201.71	250.00	243.87
3	68.1	59.465	142.42	123.27	260.52	225.50	228.86	199.78	250.00	239.86
4	79.8	68.968	36.06	30.81	261.81	223.69	228.86	197.87	250.00	235.92
5	66.1	56.619	2.35	1.98			6.37	5.45		0.00
6	69.3	58.748					6.37	5.40		0.00
7	63.4	53.280					6.37	5.35		0.00
8	62.2	51.714					6.37	5.30		0.00
9	56.3	46.390					5.28	4.35		0.00
10	53.1	43.293					5.28	4.31		0.00
11	40.2	32.484					5.28	4.27		0.00
12	38.9	31.101					5.28	4.23		0.00
13	34.4	27.251					3.01	2.39		0.00
14	32.3	25.325					3.01	2.36		0.00
15	22.1	17.165					3.01	2.34		0.00
16	23.6	18.195					3.01	2.32		0.00
17	17.9	13.641					1.69	1.29		0.00
18	17.6	13.269					1.69	1.28		0.00
19	12.1	9.056					1.69	1.26		0.00
20	13.9	10.266					1.69	1.25		0.00
21	11.7	8.553					1.07	0.79		0.00
22	12.1	8.812					1.07	0.78		0.00
23	6.9	4.933					1.07	0.77		0.00
24	8.0	5.685					1.07	0.76		0.00
25	8.0	5.616					0.92	0.65		0.00
26	6.8	4.730					0.92	0.65		0.00
27	5.3	3.686					0.92	0.64		0.00
28	4.8	3.274					0.92	0.63		0.00
29	4.3	2.923					0.63	0.43		0.00
30	3.3	2.235					0.62	0.42		0.00
31	3.3	2.187					0.62	0.41		0.00
32	3.7	2.450					0.62	0.41		0.00
Totals	1000.00	825.21	1030.28	908.38	1037.47	903.88		871.35	1000.00	967.58

III. PROFIT MARGINS CALCULATIONS

```
       P    <LN>/LN - (TU)<UTL>/LN + (PAYNUM)(PAYBEN)/LN + (RFQ)*(TI)*(4/S)*PV(SRP)/((1 + RTQ)*LN)
(17)  --- = ------------------------------------------------------------------------------------------
      LN        <P>/P - (TU)<UTP>/P - PT(1 - TU)<UTL>/P + (PAYDENOM)(PAYBEN)/P
```

COEFF1 = -PT*(1-TU) -0.0152

COEFF2 = +RFQ/(1+RTQ)*TI*4/S 0.0073

Cash Flows

Cash Flow Names:	<LN>	<P>	<UTP>	<UTL>	<SRP>	<PAYNUM>	<PAYDENOM>
Present Value: (per $1000 of cash flow)	825.21	908.38	903.88	871.35	967.58	586.19	709.63

Numerator

							SUM
Coefficient names:	1			-TU	+COEFF2	+PAYBEN	
Coefficient values:	1			-0.34	-0.0073	0.0848	
Products:	825.21			-296.26	7.09	49.73	585.77

Denominator

Coefficient names:	1	-TU	+COEFF1		+PAYBEN	
Coefficient values:	1	-0.34	-0.0152		0.0848	
Products:	908.38	-307.32	-13.23		60.20	648.03

$$P/LN = \frac{585.77}{648.03}$$

= MARKUP1 = 0.9063

P/(L+E) = 1/(1/MARKUP1 + 0.023)
= MARKUP2 = 0.8878

MARGIN = 1 - 1/MARKUP2 = -12.64%

1988-AG/SRB
100H
Exhibit 10-4

IV. INVESTMENT BALANCES

MARKUP1	0.9063
MARKUP2	0.8878
MARGIN	-12.64%

Investment Balances

QUARTER	[LN] (1)	[P] *(P/LN) (2)	[UTP] *(1-COEFF3) *(P/LN) (3)	(TU)[UTL] (4)	TOTAL1 (5)= (2)-(1) +(4)-(3)	PAY 56.94 (6)	PAY+INT (7)	TOTAL2 (8)= (5)-(7)	TOTAL2 +SRP*4/S (9)
0	8.72	81.70	0.00	2.97	75.94		0.00	75.94	75.94
1	82.47	504.15	82.81	80.83	419.70	0.00	0.00	419.70	919.70
2	152.66	780.23	167.08	160.08	620.57	0.00	0.00	620.57	1120.57
3	223.49	923.14	253.76	240.73	686.62	0.00	0.00	686.62	1186.62
4	307.22	972.20	342.37	322.81	645.41	0.00	0.00	645.41	1145.41
5	378.79	991.57	348.45	330.70	595.04	56.94	56.94	538.10	538.10
6	454.78	1009.16	354.63	338.73	538.49	0.00	57.95	480.54	480.54
7	526.28	1027.07	360.92	346.91	486.78	0.00	58.97	427.80	427.80
8	597.77	1045.28	367.32	355.23	435.42	0.00	60.02	375.40	375.40
9	664.68	1063.83	373.84	363.32	388.64	0.00	61.08	327.55	327.55
10	729.52	1082.70	380.47	371.56	344.28	0.00	62.17	282.11	282.11
11	782.65	1101.90	387.22	379.95	311.99	0.00	63.27	248.72	248.72
12	835.38	1121.45	394.09	388.49	280.47	0.00	64.39	216.08	216.08
13	884.57	1141.34	401.08	396.40	252.10	0.00	65.54	186.56	186.56
14	932.51	1161.59	408.19	404.46	225.35	0.00	66.70	158.65	158.65
15	971.12	1182.20	415.43	412.66	208.30	0.00	67.88	140.42	140.42
16	1011.97	1203.17	422.80	421.00	189.40	0.00	69.09	120.31	120.31
17	1047.80	1224.51	430.30	429.04	175.45	0.00	70.31	105.14	105.14
18	1083.95	1246.23	437.94	437.23	161.58	0.00	71.56	90.02	90.02
19	1115.28	1268.34	445.70	445.56	152.92	0.00	72.83	80.09	80.09
20	1148.91	1290.84	453.61	454.04	142.35	0.00	74.12	68.23	68.23
21	1180.94	1313.74	461.66	462.45	133.59	0.00	75.43	58.16	58.16
22	1214.01	1337.04	469.85	471.02	124.21	0.00	76.77	47.43	47.43
23	1242.39	1360.76	478.18	479.74	119.92	0.00	78.13	41.79	41.79
24	1272.40	1384.90	486.66	488.62	114.45	0.00	79.52	34.93	34.93
25	1302.92	1409.46	495.30	497.60	108.84	0.00	80.93	27.91	27.91
26	1332.80	1434.46	504.08	506.74	104.32	0.00	82.37	21.96	21.96
27	1361.76	1459.91	513.02	516.04	101.17	0.00	83.83	17.34	17.34
28	1390.69	1485.81	522.12	525.51	98.51	0.00	85.31	13.19	13.19
29	1419.65	1512.16	531.39	535.04	96.17	0.00	86.83	9.34	9.34
30	1448.16	1538.99	540.81	544.75	94.76	0.00	88.37	6.40	6.40
31	1477.13	1566.29	550.41	554.62	93.37	0.00	89.94	3.44	3.44
32	1507.04	1594.07	560.17	564.67	91.53	0.00	91.53	-0.00	-0.00
33						0.00			
Totals						56.94		6575.84	8575.84

	(1)	(2)	(3)	(4)
PV in T at 6Q	937.44	1094.11	384.48	351.24
PAYNUM	586.19			
PAYDENOM	709.63			

1988-AG/SRB
100H
Exhibit 10-5

V. INTERNAL RATE OF RETURN CALCULATIONS

SIN	SOUT	PAY+SOUT-SIN
0.00		0.000
500.00	0.00	-500.000
500.00	508.87	8.869
500.00	508.87	8.869
500.00	508.87	8.869
0.00	508.87	565.805
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
	0.00	0.000
2000.000	2035.48	92.414
	IRR	18.97%

I. PARAMETER VALUES

Variable	Formula or Source	Values Annual	Values Quarterly
MRP		9%	
TI		22.4%	
RF		6.27%	
RFQ	(1+RF)^0.25-1		1.53%
BL		-0.16	
RL	+RF+BL*$MRP	4.8%	
RLQ	(1+RL)^0.25-1		1.19%
BA		0.27	
LPA		0.32%	
RA	+RF+BA*$MRP+LPA	9.0%	
RAQ	(1+RA)^0.25-1		2.18%
RT	+RF+(1-TI)*(BA*MRP+	8.4%	
RTQ	(1+RT)^0.25-1		2.04%
G	(1-TI)*RA	7.0%	
GQ	(1+G)^0.25-1		1.71%
RATIO	(1+G)/(1+RT)	98.7%	
RATQ	+RATIO^0.25		99.67%
T			5
PAYBEN	(1-RATQ^(N-T))/(1+R FQ)^(T-.5)	0.045	
TU		34%	
PT		2.3%	
S		2	
RTI		20.7%	
EBU		0.26%	

PROPERTY DAMAGE LIABILITY MARGIN CALCULATION 01-Sep-87

1988-AG/SRB
100H
Exhibit 10-7

II. CASH FLOWS

+N 20

QUARTER	(1) LN	(2) PV [LN]	(3) P	(4) PV [P]	(5) UTP	(6) PV [UTP]	(7) UTL	(8) PV [UTL]	(9) SRP	(10) PV (SRP)
0	19.5	18.367	90.15	85.10			19.488	18.37		0.00
1	161.5	150.891	464.54	433.33	257.57	240.27	237.519	221.94	250.00	248.11
2	187.9	174.091	294.76	271.70	257.57	237.41	237.519	220.05	250.00	244.36
3	175.8	161.459	142.42	129.72	260.52	237.28	237.519	218.19	250.00	240.68
4	173.6	158.105	36.06	32.46	261.81	235.63	237.519	216.33	250.00	237.04
5	118.6	107.116	2.35	2.09			6.132	5.54		
6	59.8	53.563					6.132	5.49		
7	31.8	28.247					6.132	5.44		
8	19.9	17.496					6.132	5.40		
9	13.4	11.664					1.057	0.92		
10	10.4	8.962					1.057	0.91		
11	7.1	6.112					1.057	0.91		
12	6.3	5.377					1.057	0.90		
13	3.0	2.537					0.322	0.27		
14	3.4	2.850					0.322	0.27		
15	3.0	2.519					0.322	0.27		
16	1.8	1.495					0.322	0.26		
17	1.1	0.903					0.099	0.08		
18	0.6	0.475					0.099	0.08		
19	1.0	0.837					0.099	0.08		
20	0.5	0.364					0.099	0.08		
Totals	1000.0	913.4	1030.3	954.4	1037.5	950.6	1000.0	921.8	1000.0	970.2

III. PROFIT MARGINS CALCULATIONS

```
        P    <LN>/LN - (TU)<UTL>/LN + (PAYNUM)(PAYBEN)/LN + (RFQ)*(TI)*(4/S)*PV(SRP)/((1 + RTQ)*LN)
(17)   --- = ---------------------------------------------------------------------------------------
        LN        <P>/P - (TU)<UTP>/P - PT(1 - TU)<UTL>/P + (PAYDENOM)(PAYBEN)/P
```

COEFF1 = -PT*(1-TU) -0.0152

COEFF2 = +RFQ/(1+RTQ)*TI*4/S 0.0067

	<LN>	<P>	<UTP>	<UTL>	<SRP>	<PAYNUM>	<PAYDENOM>	SUM
Cash Flows								
Cash Flow Names:	<LN>	<P>	<UTP>	<UTL>	<SRP>	<PAYNUM>	<PAYDENOM>	
Present Value: (per $1000 of cash flow)	913.43	954.39	950.59	921.78	970.19	669.20	707.77	
Numerator								SUM
Coefficient names:	1			-TU	+COEFF2	+PAYBEN		
Coefficient values:	1			-0.34	-0.0067	0.0446		
Products:	913.43			-313.41	6.53	29.83		636.38 = P
Denominator								
Coefficient names:		1	-TU	+COEFF1			+PAYBEN	
Coefficient values:		1	-0.34	-0.0152			0.0446	
Products:		954.39	-323.20	-13.99			31.55	648.74 = LN

$$P/LN = \frac{636.38}{648.74}$$

= MARKUP1 = 0.9835

P/(L+E) = 1/(1/MARKUP1 + 0.023)
= MARKUP2 = 0.9617

MARGIN = 1 - 1/MARKUP2 = -3.98%

IV. INVESTMENT BALANCES

MARKUP1	0.9835
MARKUP2	0.9617
MARGIN	-3.98%

Investment Balances

QUARTER	[LN] (1)	[P] *(P/LN) (2)	[UTP] *(1-COEFF3) *(P/LN) (3)	(TU)[UTL] (4)	TOTAL1 (5)= (2)-(1) +(4)-(3)	PAY 26.89 (6)	PAY+INT (7)	TOTAL2 (8)= (5)-(7)	TOTAL2 +SRP*4/S (9)
0	19.49	88.66	0.00	6.63	75.80		0.00	75.80	75.80
1	181.30	547.04	89.86	87.50	363.37	0.00	0.00	363.37	863.37
2	372.30	846.27	181.26	169.74	462.46	0.00	0.00	462.46	962.46
3	554.42	1000.78	275.19	253.40	424.56	0.00	0.00	424.56	924.56
4	737.47	1053.32	371.17	338.47	283.15	0.00	0.00	283.15	783.15
5	868.66	1073.60	377.50	346.33	173.77	26.89	26.89	146.88	146.88
6	943.30	1091.91	383.94	354.33	118.99	0.00	27.35	91.64	91.64
7	991.21	1110.53	390.49	362.45	91.29	0.00	27.82	63.47	63.47
8	1027.99	1129.48	397.15	370.72	75.06	0.00	28.29	46.77	46.77
9	1058.89	1148.74	403.92	377.40	63.33	0.00	28.77	34.56	34.56
10	1087.31	1168.34	410.81	384.20	54.41	0.00	29.26	25.15	25.15
11	1112.98	1188.27	417.82	391.11	48.58	0.00	29.76	18.82	18.82
12	1138.28	1208.53	424.95	398.15	43.45	0.00	30.27	13.18	13.18
13	1160.71	1229.15	432.20	405.05	41.29	0.00	30.79	10.50	10.50
14	1183.92	1250.11	439.57	412.06	38.70	0.00	31.31	7.38	7.38
15	1207.15	1271.44	447.07	419.20	36.43	0.00	31.85	4.58	4.58
16	1229.56	1293.13	454.69	426.46	35.34	0.00	32.39	2.95	2.95
17	1251.64	1315.18	462.45	433.77	34.87	0.00	32.94	1.93	1.93
18	1273.57	1337.62	470.34	441.20	34.91	0.00	33.50	1.40	1.40
19	1296.34	1360.43	478.36	448.76	34.49	0.00	34.08	0.42	0.42
20	1318.91	1383.64	486.52	456.45	34.66	0.00	34.66	-0.00	-0.00
						0.00			
Totals						26.89		2078.36	4078.96
PV in T at 6Q	1023.37	1091.60	383.83	354.17					
PAYNUM	669.20								
PAYDENOM	707.77								

V. INTERNAL RATE OF RETURN CALCULATIONS

SIN	SOUT	PAY+SOUT-SIN
0.00		0.000
500.00	0.00	-500.000
500.00	508.53	8.529
500.00	508.53	8.529
500.00	508.53	8.529
0.00	508.53	535.420
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
0.00	0.00	0.000
	0.00	0.000
2000.00	2034.11	61.006
	IRR	12.51%

I. PARAMETER VALUES

Variable	Formula or Source	Values Annual	Values Quarterly
MRP		9%	
TI		22.4%	
RF		6.16%	
RFQ	(1+RF)^0.25-1		1.51%
BL		-0.16	
RL	+RF+BL*$MRP	4.7%	
RLQ	(1+RL)^0.25-1		1.16%
BA		0.27	
LPA		0.30%	
RA	+RF+BA*$MRP+LPA	8.9%	
RAQ	(1+RA)^0.25-1		2.15%
RT	+RF+(1-TI)*(BA*MRP+	8.3%	
RTQ	(1+RT)^0.25-1		2.01%
G	(1-TI)*RA	6.9%	
GQ	(1+G)^0.25-1		1.68%
RATIO	(1+G)/(1+RT)	98.7%	
RATQ	+RATIO^0.25		99.68%
T			5
PAYBEN	(1-RATQ^(N-T))/(1+R FQ)^(T-.5)	0.044	
TU		34%	
PT		2.3%	
S		2	
RTI		20.7%	
EBU		0.26%	

II. CASH FLOWS

+N 20

QUARTER	(1) LN	(2) PV [LN]	(3) P	(4) PV [P]	(5) UTP	(6) PV [UTP]	(7) UTL	(8) PV [UTL]	(9) SRP	(10) PV (SRP)
0	12.6	11.918	90.15	85.18			12.631	11.91		
1	190.6	178.343	464.54	433.83	257.57	240.54	246.358	230.47	250.00	248.14
2	277.4	257.389	294.76	272.06	257.57	237.74	246.358	228.55	250.00	244.46
3	237.1	218.171	142.42	129.92	260.85	237.96	246.358	226.66	250.00	240.83
4	233.8	213.280	36.06	32.51	262.30	236.48	246.358	224.78	250.00	237.26
5	111.2	100.643	2.35	2.10			0.922	0.83		
6	-13.2	-11.833					0.922	0.83		
7	-15.0	-13.383					0.922	0.82		
8	-8.4	-7.377					0.922	0.81		
9	-7.8	-6.789					-0.389	-0.34		
10	-5.7	-4.918					-0.389	-0.34		
11	-3.4	-2.904					-0.389	-0.33		
12	-3.8	-3.273					-0.389	-0.33		
13	-1.5	-1.298					-0.042	-0.04		
14	-1.4	-1.163					-0.042	-0.04		
15	-1.2	-1.029					-0.042	-0.03		
16	-0.7	-0.599					-0.042	-0.03		
17	-0.3	-0.237					-0.006	-0.00		
18	-0.1	-0.059					-0.006	-0.00		
19	-0.1	-0.117					-0.006	-0.00		
20	-0.2	-0.173					-0.006	-0.00		
Totals	1000.00	924.589	1030.276	955.60	1038.29	952.72		924.17	1000.00	970.69

III. PROFIT MARGINS CALCULATIONS

```
       P    <LN>/LN - (TU)<UTL>/LN + (PAYNUM)(PAYBEN)/LN + (RFQ)*(TI)*(4/S)*PV(SRP)/((1 + RTQ)*LN) - MOREPAY
(17') --- = ---------------------------------------------------------------------------------------------
      LN       <P>/P - (TU)<UTP>/P - PT(1 - TU)<UTL>/P + (PAYDENOM)(PAYBEN)/P
```

where:

COEFF1 =	-PT*(1-TU)	-0.0152
COEFF2 =	+RFQ/(1+RTQ)*TI*4/S	0.0066

	<LN>	<P>	<UTP>	<UTL>	<SRP>	<PAYNUM2>	<PAYDENOM>	<MOREPAY>	SUM
Cash Flow									
Cash Flow Names:	<LN>	<P>	<UTP>	<UTL>	<SRP>	<PAYNUM2>	<PAYDENOM>	<MOREPAY>	
Present Value: (per $1000 of cash flow)	924.59	955.60	952.72	924.17	970.69	748.93	706.83	2.00	
Numerator									SUM
Coefficient names:	1			-TU	-COEFF2	+PAYBEN		-1	
Coefficient values:	1			-0.34	-0.0066	0.0439		-1	
Products:	924.59			-314.22	6.42	32.88		-2.00	647.67 = P
Denominator									
Coefficient names:		1	-TU	+COEFF1			+PAYBEN		
Coefficient values:		1	-0.34	-0.0152			0.0439		
Products:		955.60	-323.92	-14.03			31.03		648.68 = LN

```
            647.67
P/LN =    ---------
            648.68
          = MARKUP1            =      1.0010

P/(L+E) = 1/(1/MARKUP1 + 0.023)
          = MARKUP2            =      0.9785

 MARGIN = 1 - 1/MARKUP2        =      -2.20%
```

IV. INVESTMENT BALANCES

MARKUP1	1.0010
MARKUP2	0.9785
MARGIN	-2.20%

Investment Balances

QUARTER	[LN] (1)	[P] *(P/LN) (2)	[UTP] *(1-COEFF3) *(P/LN) (3)	(TU)[UTL] (4)	TOTAL1 (5)= (2)-(1) +(4)-(3)	PAY -41.36 (6)	PAY+INT (7)	TOTAL2 (8)= (5)-(7)	TOTAL2 +SRP*4/S (9)
0	12.63	90.24	0.00	4.29	81.90		0.00	81.90	81.90
1	203.49	556.78	91.46	88.13	349.95	0.00	0.00	349.95	849.95
2	484.35	861.21	184.47	173.37	365.77	0.00	0.00	365.77	865.77
3	729.62	1018.26	280.15	260.05	268.54	0.00	0.00	268.54	768.54
4	975.65	1071.49	377.93	348.18	66.09	0.00	0.00	66.09	566.09
5	1103.28	1091.86	384.29	354.35	-41.36	-41.36	-41.36	0.00	0.00
6	1108.65	1110.22	390.75	360.63	-28.55	13.19	-28.86	0.31	0.31
7	1112.25	1128.89	397.33	367.01	-13.68	15.04	-14.31	0.63	0.63
8	1122.60	1147.88	404.01	373.49	-5.24	8.36	-6.19	0.96	0.96
9	1133.72	1167.18	410.80	379.64	2.30	7.76	1.46	0.84	0.84
10	1147.12	1186.81	417.71	385.89	7.87	5.67	7.15	0.72	0.72
11	1163.04	1206.77	424.74	392.25	11.25	3.37	10.65	0.60	0.60
12	1178.77	1227.07	431.88	398.71	15.14	3.83	14.66	0.48	0.48
13	1197.06	1247.70	439.14	405.41	16.91	1.53	16.44	0.47	0.47
14	1215.80	1268.69	446.53	412.21	18.57	1.38	18.10	0.47	0.47
15	1235.01	1290.02	454.04	419.13	20.10	1.24	19.64	0.46	0.46
16	1255.06	1311.72	461.67	426.16	21.15	0.73	20.70	0.45	0.45
17	1275.88	1333.78	469.44	433.33	21.79	0.29	21.33	0.46	0.46
18	1297.26	1356.21	477.33	440.61	22.23	0.07	21.77	0.47	0.47
19	1318.93	1379.02	485.36	448.02	22.75	0.15	22.28	0.47	0.47
20	1340.90	1402.21	493.52	455.55	23.35	0.22	22.87	0.48	0.48
Totals						21.47		1140.53	3140.53
PV in T at 6Q	1103.28	1090.72	383.89	354.35					
PAYNUM2	748.93								
PAYDENOM	706.83								

Number of quarters = 5

V. INTERNAL RATE OF RETURN CALCULATIONS

SIN	SOUT	PAY+SOUT-SIN
0.00		0.000
500.00	0.00	-500.000
500.00	508.41	8.409
500.00	508.41	8.409
500.00	508.41	8.409
0.00	508.41	467.054
0.00	0.00	13.186
0.00	0.00	15.039
0.00	0.00	8.359
0.00	0.00	7.757
0.00	0.00	5.666
0.00	0.00	3.374
0.00	0.00	3.834
0.00	0.00	1.533
0.00	0.00	1.385
0.00	0.00	1.236
0.00	0.00	0.726
0.00	0.00	0.290
0.00	0.00	0.073
0.00	0.00	0.145
0.00	0.00	0.217
	0.00	0.000
2000.00	2033.64	55.101
	IRR	10.23%

PAUL L. CHERNICK

PLC, Inc.
10 Post Office Square
Boston, Massachusetts 02109
(617) 451-5173

PROFESSIONAL EXPERIENCE

President, PLC, Inc.

August 1986 - present

Consulting and testimony in utility and insurance economics. Reviewin utility supply planning processes and outcomes: assessing prudence of earlier nuclear power planning investments, identifying excess generat capacity, analyzing effects of power pool pricing rules on equity and utility incentives. Reviewing electric utility rate design. Estimati magnitude and cost of future load growth. Designing electric utility conservation programs, including hook-up charges.

Determining avoided costs due to cogenerators. Negotiating cogenerati contracts. Reviewing management and pricing of district heating syster

Determining fair profit margins for automobile insurance lines, incorporating reward for risk, return on investments, and tax effects.

Research Associate, Analysis and Inference, Inc.
May, 1981 - August, 1986 (Consultant, 1980-1981)

Research, consulting and testimony in various aspects of utility and insurance regulation. Designed self-insurance pool for nuclear decommissioning; estimated probability and cost of insurable events, ar rate levels; assessed alternative rate designs. Projected nuclear powe plant construction, operation, and decommissioning costs. Assessed reasonableness of earlier estimates of nuclear power plant constructior schedules and costs. Reviewed prudence of utility construction decisions.

Consulted on utility rate design issues including small power producer rates; retail natural gas rates; public agency electric rates; and comprehensive electric rate design for a regional power agency. Developed electricity cost allocations between customer classes.

Reviewed district heating system efficiency. Proposed power plant performance standards. Analyzed auto insurance profit requirements. Designed utility-financed, decentralized conservation program. Analyze cost-effectiveness of transmission lines.

Utility Rate Analyst, Massachusetts Attorney General
December, 1977 - May, 1981

Analyzed utility filings and prepared alternative proposals. Participated in rate negotiations, discovery, cross-examination, and briefing. Provided extensive expert testimony before various regulat agencies.

Topics included: demand forecasting, rate design, marginal costs, time-of-use rates, reliability issues, power pool operations, nuclear power cost projections, power plant cost-benefit analysis, energy conservation and alternative energy development.

EDUCATION

S.M., Technology and Policy Program, Massachusetts Institute of Technology, February, 1978

S.B., Civil Engineering Department, Massachusetts Institute of Technology, June, 1974

HONORARY SOCIETIES

Chi Epsilon (Civil Engineering)
Tau Beta Pi (Engineering)
Sigma Xi (Research)

OTHER HONORS

Institute Award, Institute of Public Utilities, 1981

PUBLICATIONS

Chernick, P., "The Relevance of Regulatory Review of Utility Planning Prudence in Major Power Supply Decisions," in Current Issues Challen the Regulatory Process, Center for Public Utilities, Albuquerque, Ne Mexico, April, 1987 (in press).

Chernick, P., "Power Plant Phase-In Methodologies: Alternatives to Ra Shock," in Proceedings of the Fifth NARUC Biennial Regulatory Information Conference, National Regulatory Research Institute, Columbus, Ohio, September, 1986, pp. 547-562.

Bachman, A. and Chernick, P., "Assessing Conservation Program Cost-Effectiveness: Participants, Non-participants, and the Utility System," in Proceedings of the Fifth NARUC Biennial Regulatory Information Conference, National Regulatory Research Institute Columbus, Ohio, September, 1986, pp. 2093-2110.

Eden, P., Fairley, W., Aller, C., Vencill, C., Meyer, M., and Chernick, P., "Forensic Economics and Statistics: An Introduction to the Current State of the Art," The Practical Lawyer, June 1, 1985, pp. 25-36.

Chernick, P., "Power Plant Performance Standards: Some Introductory Principles," Public Utilities Fortnightly, April 18, 1985, pp. 29-33

Chernick, P., "Opening the Utility Market to Conservation: A Compr Approach," in Energy Industries in Transition, 1985-2000, Proceeding the Sixth Annual North American Meeting of the International Associa of Energy Economists, San Francisco, California, November, 1984, pp. 1133-1145.

Meyer, M., Chernick, P., and Fairley, W., "Insurance Market Assessment Technological Risks," in Risk Analysis in the Private Sector, pp. 401-416, Plenum Press, New York, 1985.

Chernick, P., "Revenue Stability Target Ratemaking," Public Utilities Fortnightly, February 17, 1983, pp. 35-39.

Chernick, P. and Meyer, M., "Capacity/Energy Classifications and Allocations for Generation and Transmission Plant," in Award Papers Public Utility Economics and Regulation, Institute for Public Utilit Michigan State University, 1982.

Chernick, P., Fairley, W., Meyer, M., and Scharff, L., Design, Costs and Acceptability of an Electric Utility Self-Insurance Pool for Assuring the Adequacy of Funds for Nuclear Power Plant Decommissioni Expense (NUREG/CR-2370), U.S. Nuclear Regulatory Commission, Decembe 1981.

PUBLICATIONS CONTINUE

Chernick, P., Optimal Pricing for Peak Loads and Joint Production: Theory and Applications to Diverse Conditions (Report 77-1), Technology and Policy Program, Massachusetts Institute of Technolog September, 1977.

PRESENTATIONS

New England Utility Rate Forum; Plymouth, Massachusetts, October 11, "Lessons from Massachusetts on Long Term Rates for QF's".

National Association of State Utility Consumer Advocates; Williamstow Massachusetts, August 13, 1984; "Power Plant Performance".

National Conference of State Legislatures; Boston, Massachusetts, August 6, 1984; "Utility Rate Shock".

National Governors' Association Working Group on Nuclear Power Cost Overruns; Washington, D.C., June 20, 1984; "Review and Modification o Regulatory and Rate Making Policy".

Annual Meeting of the American Association for the Advancement of Sci Session on Monitoring for Risk Management; Detroit, Michigan, May 27, "Insurance Market Assessment of Technological Risks".

EXPERT TESTIMONY

In each entry, the following information is presented in order: jurisdiction and docket number; title of case; client; date testimony filed; and subject matter covered. Abbreviations of jurisdictions include MDPU (Massachusetts Department of Public Utilities); MEFSC (Massachusetts Energy Facilities Siting Council); PSC (Public Service Commission): and PU (Public Utilities Commission).

1. MEFSC 78-12/MDPU 19494, Phase I; Boston Edison 1978 forecast; Massachusetts Attorney General; June 12, 1978.

   Appliance penetration projections, price elasticity, econometric commercial forecast, peak demand forecast. Joint testimony with S.C. Geller.

2. MEFSC 78-17; Northeast Utilities 1978 forecast; Massachusetts Attorney General; September 29, 1978.

   Specification of economic/demographic and industrial models, appliance efficiency, commercial model structure and estimation.

3. MEFSC 78-33; Eastern Utilities Associates 1978 forecast; Massachusetts Attorney General; November 27, 1978.

   Household size, appliance efficiency, appliance penetration, price elasticity, commercial forecast, industrial trending, peak demand forecast.

4. MDPU 19494, Phase II; Boston Edison Company Construction Program; Massachusetts Attorney General; April 1, 1979.

   Review of numerous aspects of the 1978 demand forecasts of nine New England electric utilities, constituting 92% of projected regional demand growth, and of the NEPOOL demand forecast. Joint testimony with S.C. Geller.

5. MDPU 19494. Phase II; Boston Edison Company Construction Program; Massachusetts Attorney General; April 1, 1979.

   Reliability, capacity planning, capability responsibility allocation, customer generation, co-generation rates, reserve margins, operating reserve allocation. Joint testimony with S. Finger.

6. Atomic Safety and Licensing Board, Nuclear Regulatory Commission 50-471; Pilgrim Unit 2, Boston Edison Company; Commonwealth of Massachusetts; June 29, 1979.

   Review of the Oak Ridge National Laboratory and the NEPOOL demand forecast models; cost-effectiveness of oil deplacement; nuclear economics. Joint testimony with S.C. Geller.

7. MDPU 19845; Boston Edison Time-of-Use Rate Case; Massachusetts Attorney General; December 4, 1979.

   Critique of utility marginal cost study and proposed rates; principles of marginal cost principles, cost derivation, and rate design; options for reconciling costs and revenues. Joint testimon with S.C. Geller. Testimony eventually withdrawn due to delay in case.

8. MDPU 20055; Petition of Eastern Utilities Associates, New Bedford G & E., and Fitchburg G. & E. to purchase additional shares of Seabrook Nuclear Plant; Massachusetts Attorney General; January 23, 1980.

   Review of demand forecasts of three utilities purchasing Seabrook shares, Seabrook power costs, including construction cost, completion date, capacity factor, O & M expenses, interim replacements, reserves and uncertainties; alternative energy sources, including conservation, cogeneration, rate reform, solar, wood and coal conversion.

9. MDPU 20248; Petition of MMWEC to Purchase Additional Share of Seabrook Nuclear Plant; Massachusetts Attorney General; June 2, 1980.

   Nuclear power costs; update and extension of MDPU 20055 testimony.

10. MDPU 200; Massachusetts Electric Company Rate Case; Massachusetts Attorney General; June 16, 1980.

    Rate design; declining blocks, promotional rates, alternative energy, demand charges, demand ratchets; conservation: master metering, storage heating, efficiency standards, restricting resistance heating.

11. MEFSC 79-33; Eastern Utilities Associates 1979 Forecast; Massachusetts Attorney General; July 16, 1980.

    Customer projections, consistency issues, appliance efficiency, new appliance types, commercial specifications, industrial data manipulation and trending, sales and resale.

12. MDPU 243; Eastern Edison Company Rate Case; Massachusetts Attorney General; August 19, 1980.

    Rate design: declining blocks, promotional rates, alternative energy, master metering.

13. Texas PUC 3298; Gulf States Utilities Rate Case; East Texas Legal Services; August 25, 1980.

    Inter-class revenue allocations, including production plant in service, O & M, CWIP, nuclear fuel in progress, amortization of cancelled plant residential rate design; interruptible rates; off-peak rates. Joint testimony with M.B. Meyer.

14. MEFSC 79-1; Massachusetts Municipal Wholesale Electric Company Forecast; Massachusetts Attorney General; November 5, 1980.

Cost comparison methodology; nuclear cost estimates; cost of conservation, cogeneration, and solar.

15. MDPU 472; Recovery of Residential Conservation Service Expenses; Massachusetts Attorney General; December 12, 1980.

Conservation as an energy source; advantages of per-kwh allocation over per customer month allocation.

16. MDPU 535; Regulations to Carry Out Section 210 of PURPA; Massachusetts Attorney General; January 26, 1981 and February 13, 1981.

Filing requirements, certification, qualifying facility (QF) status extent of coverage, review of contracts; energy rates; capacity rates; extra benefits of QFs in specific areas; wheeling; standardization of fees and charges.

17. MEFSC 80-17; Northeast Utilities 1980 Forecast; Massachusetts Attorney General; March 12, 1981 (not presented).

Specification process, employment, electric heating promotion and penetration, commercial sales model, industrial model specification documentation of price forecast and wholesale forecast.

18. MDPU 558; Western Massachusetts Electric Company Rate Case; Massachusetts Attorney General; May, 1981.

Rate design; declining blocks, marginal cost, conservation impacts, promotional rates; conservation: terms and conditions limiting renewables, cogeneration, small power production; scope of current conservation program; efficient insulation levels; additional conservation opportunities.

19. MDPU 1048; Boston Edison Plant Performance Standards; Massachusetts Attorney General; May 7, 1982.

Critique of company approach, data, and statistical analysis; description of comparative and absolute approaches to standard-setting; proposals for standards and reporting requirements.

20. DCPSC FC785; Potomac Electric Power Rate Case; DC People's Counsel; July 29, 1982.

Inter-class revenue allocations, including generation, transmission, and distribution plant classification; fuel and O & M classification; distribution and service allocators. Marginal cost estimation, including losses.

21. NHPUC DE81-312; Public Service of New Hampshire - Supply and Deman Conservation Law Foundation, et al.; October 8, 1982.

Conservation program design, ratemaking, and effectiveness. Cost power from Seabrook nuclear plant, including construction cost and duration, capacity factor, O & M, replacements, insurance, and decommissioning.

22. Massachusetts Division of Insurance; Hearing to Fix and Establish 1983 Automobile Insurance Rates; Massachusetts Attorney General; October, 1982.

Profit margin calculations, including methodology, interest rates, surplus flow, tax flows, tax rates, and risk premium.

23. Illinois Commerce Commission 82-0026; Commonwealth Edison Rate Cas Illinois Attorney General; October 15, 1982.

Review of Cost-Benefit Analysis for nuclear plant. Nuclear cost parameters (construction cost, O & M, capital additions, useful life, capacity factor), risks, discount rates, evaluation techniques.

24. New Mexico Public Service Commission 1794; Public Service of New Mexico Application for Certification; New Mexico Attorney General; May 10, 1983.

Review of Cost-Benefit Analysis for transmission line. Review of electricity price forecast, nuclear capacity factors, load forecas Critique of company ratemaking proposals; development of alternati ratemaking proposal.

25. Connecticut Public Utility Control Authority 830301; United Illuminating Rate Case; Connecticut Consumers Counsel; June 17, 1983.

Cost of Seabrook nuclear power plants, including construction cost and duration, capacity factor, O & M replacements, insurance and decommissioning.

26. MDPU 1509; Boston Edison Plant Performance Standards; Massachusetts Attorney General; July 15, 1983.

Critiquing of company approach and statistical analysis; regression model of nuclear capacity factor; proposals for standards and for standard-setting methodologies.

27. Massachusetts Division of Insurance; Hearing to Fix and Establish 1984 Automobile Insurance Rates; Massachusetts Attorney General; October, 1983.

Profit margin calculations, including methodology, interest rates, surplus flow, tax rates, and recognition of risk.

28. Connecticut Public Utility Control Authority 83-07-15; Connecticut Light and Power Rate Case; Alloy Foundry; October 3, 1983.

Industrial rate design. Marginal and embedded costs; classificat of generation, transmission, and distribution expenses; demand versus energy charges.

29. MEFSC 83-24; New England Electric System Forecast of Electric Resources and Requirements; Massachusetts Attorney General; Novemb 14, 1983, Rebuttal, February 2, 1984.

Need for transmission line. Status of supply plan, especially Seabrook 2. Review of interconnection requirements. Analysis of cost-effectiveness for power transfer, line losses, generation assumptions.

30. Michigan PSC U-7775; Detroit Edison Fuel Cost Recovery Plan; Publi Interest Research Group in Michigan; February 21, 1984.

Review of proposed performance target for new nuclear power plant. Formulation of alternative proposals.

31. MDPU 84-25; Western Massachusetts Electric Company Rate Case; Mass Attorney General; April 6, 1984.

Need for Millstone 3. Cost of completing and operating unit, cost-effectiveness compared to alternatives, and its effect on rates. Equity and incentive problems created by CWIP. Design Millstone 3 phase-in proposals to protect ratepayers: limitatio base-rate treatment to fuel savings benefit of unit.

32. MDPU 84-49 and 84-50; Fitchburg Gas & Electric Financing Case; Massachusetts Attorney General; April 13, 1984.

Cost of completing and operating Seabrook nuclear units. Probability of completing Seabrook 2. Recommendations regarding FG&E and MDPU actions with respect to Seabrook.

33. Michigan PSC U-7785; Consumers Power Fuel Cost Recovery Plan; Publi Interest Research Group in Michigan; April 16, 1984.

Review of proposed performance targets for two existing and two new nuclear power plants. Formulation of alternative proposal.

34. FERC ER81-749-000 and ER82-325-000; Montaup Electric Rate Cases; Massachusetts Attorney General; April 27, 1984.

Prudence of Montaup and Boston Edison in decisions regarding Pilgri 2 construction: Montaup's decision to participate, the utilities' failure to review their earlier analyses and assumptions, Montaup's failure to question Edison's decisions, and the utilities' delay in canceling the unit.

35. Maine PUC 84-113; Seabrook 1 Investigation; Maine Public Advocate; September 13, 1984.

    Cost of completing and operating Seabrook Unit 1. Probability of completing Seabrook 1. Comparison of Seabrook to alternatives. Rate effects. Recommendations regarding utility and PUC actions with respect to Seabrook.

36. MDPU 84-145; Fitchburg Gas and Electric Rate Case; Massachusetts Attorney General; November 6, 1984.

    Prudence of Fitchburg and Public Service of New Hampshire in decision regarding Seabrook 2 construction: FGE's decision to participate, the utilities' failure to review their earlier analy and assumptions, FGE's failure to question PSNH's decisions, and utilities' delay in halting construction and canceling the unit. Review of literature, cost and schedule estimate histories, cost-benefit analyses, and financial feasibility.

37. Pennsylvania PUC R-842651; Pennsylvania Power and Light Rate Case; Pennsylvania Consumer Advocate; November, 1984.

    Need for Susquehanna 2. Cost of operating unit, power output, cost-effectiveness compared to alternatives, and its effect on rates. Design of phase-in and excess capacity proposals to protec ratepayers: limitation of base-rate treatment to fuel savings benefit of unit.

38. NHPUC 84-200; Seabrook Unit 1 Investigation; New Hampshire Public Advocate; November 15, 1984.

    Cost of completing and operating Seabrook Unit 1. Probability of completing Seabrook 1. Comparison of Seabrook to alternatives. Rate and financial effects.

39. Massachusetts Division of Insurance; Hearing to Fix and Establish 1985 Automobile Insurance Rates; Massachusetts Attorney General; November, 1984.

    Profit margin calculations, including methodology and implementation.

40. MDPU 84-152; Seabrook Unit 1 Investigation; Massachusetts Attorney General; December 12, 1984.

    Cost of completing and operating Seabrook. Probability of completing Seabrook 1. Seabrook capacity captors.

41. Maine PUC 84-120; Central Maine Power Rate Case; Maine PUC Staff. December 11, 1984.

Prudence of Central Maine Power and Boston Edison in decisions regarding Pilgrim 2 construction: CMP's decision to participate, th utilities' failure to review their earlier analyses and assumptions CMP's failure to question Edison's decisions, and the utilities' delay in canceling the unit. Prudence of CMP in the planning and investment in Sears Island nuclear and coal plants. Review of literature, cost and schedule estimate histories, cost-benefit analyses, and financial feasibility.

42. Maine PUC 84-113; Seabrook 2 Investigation; Maine PUC Staff; December 14. 1984.

Prudence of Maine utilities and Public Service of New Hampshire in decisions regarding Seabrook 2 construction: decisions to participate and to increase ownership share, the utilities' failure to review their earlier analyses and assumptions, failure to question PSNH's decisions, and the utilities' delay in halting construction and canceling the unit. Review of literature, cost an schedule estimate histories, cost-benefit analyses, and financial feasibility.

43. MDPU 1627; Massachusetts Municipal Wholesale Electric Company Financing Case; Massachusetts Executive Office of Energy Resources; January 14, 1985.

Cost of completing and operating Seabrook nuclear unit 1. Cost of conservation and other alternatives to completing Seabrook. Comparison of Seabrook to alternatives.

44. Vermont PSB 4936; Millstone 3: Costs and In-Service Date; Vermont Department of Public Service; January 21, 1985.

Construction schedule and cost of completing Millstone Unit 3.

45. MDPU 84-276; Rules Governing Rates for Utility Purchases of Power from Qualifying Facilities; Massachusetts Attorney General; March 25, 1985, and October 18, 1985.

Institutional and technological advantages of Qualifying Facilities (QF's). Potential for QF development. Goals of QF rate design. Parity with other power sources. Security requirements. Projectin avoided costs. Capacity credits. Pricing options. Line loss corrections.

46. MDPU 85-121; Investigation of the Reading Municipal Light Department; Wilmington (MA) Chamber of Commerce; November 12, 1985.

Calculation of return on investment for municipal utility. Treatment of depreciation and debt for ratemaking. Geographical discrimination in streetlighting rates. Relative size of volunt payments to Reading and other towns. Surplus and disinvestment. Revenue allocation.

47. Massachusetts Division of Insurance; Hearing to Fix and Establish 1986 Automobile Insurance Rates; Massachusetts Attorney General ar State Rating Bureau; November, 1985.

Profit margin calculations, including methodology, implementation, modeling of investment balances, income, and return to shareholde:

48. New Mexico Public Service Commission 1833 Phase II; El Paso Elect: Rate Case; New Mexico Attorney General; December 23, 1985.

Nuclear decommissioning fund design. Internal and external funds; risk and return; fund accumulation; recommendations. Interim performance standard for Palo Verde Nuclear plant.

49. Pennsylvania PUC R-850152; Philadelphia Electric Rate Case; Utilit Users Committee and University of Pennsylvania; January 14, 1986.

Limerick 1 rate effects. Capacity benefits, fuel savings, operati costs, capacity factors, and net benefits to ratepayers. Design c phase-in proposals.

50. MDPU 85-270; Western Massachusetts Electric Rate Case; Massachuset Attorney General; March 19, 1986.

Prudence of Northeast Utilities in generation planning related to Millstone 3 construction: decisions to start and continue construction, failure to reduce ownership share, failure to pursue alternatives. Review of industry literature, cost and schedule histories, and retrospective cost-benefit analyses.

Current need for power and cost-effectiveness of Millstone 3 for ratepayers. Identification of economically useful and useless investments. Ratemaking recommendations for generation planning penalty and for phase-in.

51. Pennsylvania PUC R-850290; Philadelphia Electric Auxiliary Service Rates; Albert Einstein Medical Center, University of Pennsylvania and AMTRAK; March 24, 1986.

Review of utility proposals for supplementary and backup rates for small power producers and cogenerators. Load diversity, cost of peaking capacity, value of generation, price signals, and incentives. Formulation of alternative supplementary rate.

52. New Mexico Public Service Commission 2004; Public Service of New Mexico, Palo Verde Issues; New Mexico Attorney General; May 7, 198

Recommendations for Power Plant Performance Standards for Palo Ver nuclear units 1, 2, and 3.

53. Illinois Commerce Commission 86-0325; Iowa-Illinois Gas and El Co. Rate Investigation; Illinois Office of Public Counsel; Aug. 13, 1986.

Determination of excess capacity based on reliability and econom concerns. Identification of specific units associated with exces capacity. Required reserve margins.

54. New Mexico Public Service Commission 2009; El Paso Electric Rate Moderation Program; New Mexico Attorney General; August 18, 1986. (Not presented).

Prudence of EPE in generation planning related to Palo Verde nucl construction, including failure to reduce ownership share and failure to pursue alternatives. Review of industry literature, and schedule histories, and retrospective cost-benefit analyses.

Recommendation for rate-base treatment; proposal of power plant performance standards.

55. City of Boston, Public Improvements Commission; Transfer of Bost Edison District Heating Steam System to Boston Thermal Corporatio Boston Housing Authority; December 18, 1986.

History and economics of steam system; possible motives of Boston Edison in seeking sale; problems facing Boston Thermal; informati and assurances required prior to Commission approval of transf

56. Massachusetts Division of Insurance; Hearing to Fix and Establish 1987 Automobile Insurance Rates; Massachusetts Attorney General a State Rating Bureau; December 1986 and January 1987.

Profit margin calculations, including methodology, implementation derivation of cashflows, installment income, income tax status and return to shareholders.

57. MDPU 87-19; Petition for Adjudication of Development Facilitation Program; Hull (MA) Municipal Light Plant; January 21, 1987.

Estimation of potential load growth; cost of generation, transmission, and distribution additions. Determination of hook-u charges. Development of residential load estimation procedure reflecting appliance ownership, dwelling size.

58. New Mexico Public Service Commission 2004; Public Service of New Mexico Nuclear Decommisssioning Fund; New Mexico Attorney General; February 19, 1987.

Decommissioning cost and likely operating life of nuclear plants. Review of utility funding proposal. Development of alternative proposal. Ratemaking treatment.

59. MDPU 86-280; Western Massachusetts Electric Rate Case; Massachusetts Energy Office; March 9, 1987.

Marginal cost rate design issues. Superiority of long-run marginal cost over short-run marginal cost as basis, for rate design. Relationship of consumer reaction, utility planning process, and regulatory structure to rate design approach. Implementation of short-run and long-run rate designs. Demand versus energy charges, economic development rates, spot pricing

60. Massachusetts Division of Insurance 87-9; 1987 Workers' Compensation Rate Filing; State Rating Bureau; May 1987.

Profit margin calculations, including methodology, implementation, surplus requirements, investment income, and effects of 1986 Tax Reform Act.

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100I

AGE/SYMBOL DRIFT

SUMMARY OF SCHEDULE 100I

Company Attorney General

Line of Business Private Passenger

Rates Effective January 1, 1988

ADJUSTMENT FOR SYMBOL DRIFT

Coverage

Collision	-.134
Limited Collision.................................	-.091
Comprehensive	-.252
All Other Coverages	.000

*The Attorney General adopts this position of the MARB on this issue.

[redacted]

[redacted]

[redacted]

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100J

CURRENT AVERAGE RATES

SUMMARY OF SCHEDULE 100J

Company ______ Attorney General ______

Line of Business ______ Private Passenger ______

Rates Effective ______ January 1, 1988 ______

CURRENT AVERAGE RATES

Coverage	
A-1 10/20 Limits	$ 71.37
A-2, PIP	20.73
B, Basic 10/20 Limits	15.89
PDL, Basic	125.26
Collision $300 deductible	212.47
Limited Collision $300 deductible	35.59
D, Medical Payments	15.89
E, Comprehensive $300 deductible	99.32
U 10/20 Limits	20.62

* The Attorney General adopts the position of the MARB on this issue.

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 100X

SUBSTITUTE TRANSPORTATION

SUBSTITUTE TRANSPORTATION

The Attorney General adopts the position of the MARB on this issue.

[redacted]

[redacted]

[redacted]

ATTORNEY GENERAL

PRIVATE PASSENGER AUTOMOBILE INSURANCE
PROPOSED 1/1/88 RATES

SECTION 101

INCREASED LIMITS FACTORS

1988 AG
Schedule 101A

1988 Massachusetts Private Passenger Automobile
Summary of Coverage B Increased Limits Factors

Limit	1986 Exposures	Increased Limits Factor Indicated	Increased Limits Factor Proposed
15/30	55,557.9	1.239	1.24
20/40	271,892.4	1.382	1.36
20/50	47,177.7	1.382	1.40
25/50	291,756.7	1.489	1.47
25/60	20,795.4	1.489	1.51
All Other	55,868.3	1.489	1.55
	13,967.1	1.813	
50/100	482,329.8	1.813	1.81
100/300	901,962.8	2.179	2.18
250/500	165,072.7	2.788	2.79
500/1000	6,256.8		3.19

1988 Massachusetts Private Passenger Automobile
Development of Loss Pure Premium Increased Limits Factor
Formulae explained elsewhere.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Limit Value	Layer of Losses Between bj-1 and bj	Layer of Losses Between bj-1 and bj/f	Portion of Losses to be Transferred out of Layer Bj by Trending	Exposures of Vehicles Insured for Limit bj	Cumulative Exposures	Adjusted Layer of Losses	Layer Pure Premium	Cumulative Layer Pure Premium	Indicated Increased Limit Factor	Proposed Loss Pure Premium Increased Limits Factors
j	bj	Bj	Xj	Tj	Ej	CEj	Aj	PPj	CPPj	Ij	
0	10,000	190,063,345	184,803,490	5,259,855	791,157	3,103,795	176,803,654	77.53	77.53	1.000	1.000
1	15,000	17,115,484	14,188,033	2,927,451	55,558	2,312,638	23,660,578	18.53	96.06	1.239	1.239
2	20,000	11,747,545	8,913,888	2,833,657	319,070	2,257,080	13,023,191	11.12	107.18	1.382	1.382
3	25,000	7,594,786	5,293,012	2,301,774	368,420	1,938,010	8,153,247	8.29	115.47	1.489	1.489
4	50,000	18,886,559	16,846,984	2,039,575	496,297	1,569,590	19,147,136	25.08	140.55	1.813	1.813
5	100,000	14,130,123	12,775,772	1,354,351	901,963	1,073,293	14,419,709	28.38	168.93	2.179	2.179
6	above 100,000	3,618,815	3,618,815	0	171,330	171,330	3,838,686	47.21	216.14	2.788	2.788

045

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Data Sources and Formulae for Schedule 101A-1, Page 1

Col. (3): Data Base Reference 11

Col. (4): Data Base Reference 11

Col. (5): $T_j = B_j - X_j$

Col. (6): 101A-4

Col. (7): $\sum_{i=j}^{9} E_i$

Col. (8): $A_j = (ALD_j \times X_j) + (ALD_{j-1} \times T_{j-1} \left(\frac{CE_j}{CE_{j-1}} \right))$

A_0 and A_1 also include adjustments calculated on 101A-1, page 3.

Col. (9): $PP_j = (((A_j \times LDF_j) + (ALAE_j \times LDF_0))/CE_j) \times f \times f_2 \times M$

Col. (10): $CPP_j = \sum_{i=0}^{j} PP_i$

Col. (11): $I_j = \frac{CPP_j}{PP_0}$

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Development of Loss Pure Premium Increases Limit Factor

B, Increased Limits
Notes

MODIFICATIONS INCLUDED IN THE DETERMINATION OF Aj IN COLUMN (8)

1. Allocated Loss Adjustment Expense (1988 AG 101A-3, page 1, column 5)
Is included as follows:

Layer	Amount
0.00	9,722,722.00
1.00	999,228.00
2.00	975,222.00
3.00	732,691.00
4.00	1,610,669.00
5.00	1,101,383.00
6.00	231,334.00
Total	15,373,249.00

2. Losses in Layer 0 are modified to equal the basic limits loss pure premium for A-1 and B:

A)	A-1 and B loss and ALAE (1988 AG 100A, pp.1,2)	194,590,050.00
B)	Basic limits trend factor (1988 AG 100C-1)	1.042
C)	Trended basic limits losses - (A) x (B)	202,762,832.10
D)	Layer 0 loss from 101A Page 1 Column (4)	184,803,490.00
E)	Layer 0 ALAE from above	9,722,722.00
F)	Trend factor (f)	1.068
G)	Trended layer 0 [(D) + (E)] x f	207,753,994.00
H)	Adjustment to layer 0 after trend (C) - (G)	(4,991,162.00)
I)	Adjustment to layer 0 before trend (H)/f	(4,673,373.00)
J)	Adjustment to layer 1 before trend	4,673,373.00

FACTORS FOR COLUMN 9

Layer	f (cost trend)	f2 (freq trend)	LDF	ALD #	M *
0.00	1.068	1.00	1.2080	0.982	1.00
1.00	1.068	1.00	1.5795	1.067	1.04
2.00	1.068	1.00	1.6450	1.119	1.04
3.00	1.068	1.00	1.6828	1.026	1.03
4.00	1.068	1.00	1.7316	1.023	1.05
5.00	1.068	1.00	1.7916	1.017	1.05
6.00	1.068	1.00	1.8242	1.000	1.04

* 1988 MARB 100C-8, Exhibit 4 p.1.
\# Accident Limit Discount from 1988 AG 101A-5.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Calculation of Increased Limits Development Factors by Layer
Bodily Injury Coverages

SMOOTHING OF LOSS DEVELOPMENT FACTORS

Basic Limits (10/20) Incurred Development Factor = 1.2080[1] (Also Applies to ALAE at all layers)

Over 10,000/20,000 Incurred Limits Development Factor = 1.6841[2]

Layer	(1) % of Losses in Layer*	(2) Midpoint of Layer+	(3) Indicated LDF@	(4) Fitted LDF**	(5) =(4) x fj Adjusted LDF++
1	0.2877	0.1438	1.6098	1.5892	1.5795
2	0.1584	0.3669	1.6303	1.6552	1.6450
3	0.0991	0.4956	1.6721	1.6932	1.6828
4	0.2328	0.6616	1.7686	1.7423	1.7316
5	0.1753	0.8657	1.8018	1.8027	1.7916
6	0.0467	0.9767	2.2344	1.8355	1.8242
Total	1.0000	Avg. (weighted by column 1)		1.6945	

1. See 1988 AG Schedule 100B.
2. Source of average increased limits paid development factor: 1988 AG Schedule 101A-2, Page 8.

* See 1988 AG Schedule 101A, Line 9 for distribution of losses.

** Column (2) was used as the X-value, and Column (3) was used as the Y-value to calculate a least squares fitted line to the data. Layers 1-5 only were used to fit the line. The fitted line is Y=1.5467 + 0.2957X

\+ Sum of column (1) for all lower layers plus one-half of column (1) for present layer.

@ 1988 AG 101A-2 Pages 2-7

++ f(j)=1.0000 for j=0

$$0.9939 = \frac{1.6841}{1.6945}$$

for j > 0

Massachusetts Private Passenger Automobile
Incurred Losses by Layer
for Bodily Injury Coverage

Layer $10,001 - $15,000

Accident Year	1st	2nd	3rd	4th	5th
1977	5,906,748	7,182,795	8,240,911	8,594,734	8,880,982
1978	6,019,072	8,013,762	9,485,643	10,039,505	10,341,711
1979	7,977,378	10,442,088	12,089,086	12,667,994	12,860,381
1980	10,346,656	13,699,488	15,313,644	16,310,506	16,446,534
1981	12,208,223	15,349,004	17,284,473	18,139,635	18,562,363
1982	13,204,541	16,933,967	18,359,961	19,327,085	19,687,844
1983	14,074,005	18,756,175	21,574,201	23,018,388	
1984	15,840,986	21,037,438	23,978,385		
1985	17,379,405	23,479,194			
1986	17,115,484				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1977	1.2160	1.1473	1.0429	1.0333
1978	1.3314	1.1837	1.0584	1.0301
1979	1.3090	1.1577	1.0479	1.0152
1980	1.3240	1.1178	1.0651	1.0083
1981	1.2573	1.1261	1.0495	1.0233
1982	1.2824	1.0842	1.0527	1.0187
1983	1.3327	1.1502	1.0669	
1984	1.3280	1.1398		
1985	1.3510			
Weighted Average*	1.3219	1.1281	1.0575	1.0208

1st/5th Development Factor 1.6098

* Weights given in 1988 MARB, 101B-2, p.2.
Source: Latest diagonal - Ref. Code 19, 20;
Prior Data - Database and Marb filing for 1987 rates.

Massachusetts Private Passenger Automobile
Incurred Losses by Layer
for Bodily Injury Coverage

$15,001 - $20,000

Accident Year	1st	2nd	3rd	4th	5th
1977	4,121,262	4,989,697	5,702,692	5,963,157	6,199,565
1978	4,337,104	5,831,264	6,824,747	7,176,813	7,404,376
1979	5,819,870	7,592,100	8,585,495	9,123,517	9,261,908
1980	7,562,694	9,932,253	11,007,849	11,651,402	11,895,995
1981	8,789,510	10,854,038	12,282,931	12,958,406	13,251,139
1982	9,226,281	11,912,725	13,065,709	13,809,045	14,152,134
1983	9,729,469	13,011,769	15,272,109	16,412,055	
1984	10,924,940	14,499,404	16,532,431		
1985	12,003,610	15,956,836			
1986	11,747,545				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1977	1.2107	1.1429	1.0457	1.0396
1978	1.3445	1.1704	1.0516	1.0317
1979	1.3045	1.1308	1.0627	1.0152
1980	1.3133	1.1083	1.0585	1.0210
1981	1.2349	1.1316	1.0550	1.0226
1982	1.2912	1.0968	1.0569	1.0248
1983	1.3374	1.1737	1.0746	
1984	1.3272	1.1402		
1985	1.3293			
Weighted Average*	1.3152	1.1384	1.0635	1.0238

1st/5th Development Factor 1.6303

* Weights given in 1988 MARB, 101B-2, p.2.

Source: Latest diagonal - Ref. Code 19, 20;
Prior Data - Database and MARB filing for 1987 rates.

Massachusetts Private Passenger Automobile
Incurred Losses by Layer
for Bodily Injury Coverage

$20,001 - $25,000

Accident Year	1st	2nd	3rd	4th	5th
1977	2,373,076	2,818,783	3,279,459	3,424,239	3,547,892
1978	2,288,028	3,206,459	3,794,088	4,117,919	4,235,541
1979	3,144,364	4,153,552	4,734,159	5,108,152	5,250,592
1980	4,278,059	5,816,085	6,404,515	6,845,064	7,041,781
1981	5,245,011	6,433,633	7,505,881	8,019,931	8,226,442
1982	5,472,112	7,193,866	8,034,663	8,505,822	8,667,813
1983	6,081,486	8,168,344	9,884,384	10,385,054	
1984	6,662,145	8,973,430	10,444,894		
1985	7,628,263	10,169,547			
1986	7,594,786				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1977	1.1878	1.1634	1.0441	1.0361
1978	1.4014	1.1833	1.0854	1.0286
1979	1.3210	1.1398	1.0790	1.0279
1980	1.3595	1.1012	1.0688	1.0287
1981	1.2266	1.1667	1.0685	1.0257
1982	1.3146	1.1169	1.0586	1.0190
1983	1.3431	1.2101	1.0507	
1984	1.3469	1.1640		
1985	1.3331			
Weighted Average*	1.3252	1.1668	1.0581	1.0221

1st/5th Development Factor 1.6721

* Weights given in 1988 MARB, 101B-2, p.2.

Source: Latest diagonal - Ref. Code 19, 20;
Prior Data - Database and MARB filing for 1987 rates.

Massachusetts Private Passenger Automobile
Incurred Losses by Layer
for Bodily Injury Coverage

Layer $25,001 - $50,000

Accident Year	1st	2nd	3rd	4th	5th
1977	5,339,584	6,687,188	8,235,023	8,884,070	9,545,836
1978	5,480,671	8,012,266	9,578,056	10,385,692	10,659,350
1979	7,697,699	10,303,748	11,778,273	12,906,795	13,361,046
1980	10,702,752	14,517,774	16,231,258	17,681,337	18,139,428
1981	13,767,131	17,068,080	19,956,128	21,380,558	21,964,743
1982	13,561,917	18,042,907	20,763,872	22,623,251	22,980,968
1983	14,658,180	20,743,230	25,118,228	25,965,491	
1984	14,964,854	21,673,814	25,274,075		
1985	17,731,359	24,718,100			
1986	18,886,559				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1977	1.2524	1.2315	1.0788	1.0745
1978	1.4619	1.1954	1.0843	1.0263
1979	1.3385	1.1431	1.0958	1.0352
1980	1.3565	1.1180	1.0893	1.0259
1981	1.2398	1.1692	1.0714	1.0273
1982	1.3304	1.1508	1.0895	1.0158
1983	1.4151	1.2109	1.0337	
1984	1.4483	1.1661		
1985	1.3940			
Weighted Average*	1.3869	1.1757	1.0624	1.0210

1st/5th Development Factor 1.7686

* Weights given in 1988 MARB, 101B-2, p.2.
Source: Latest diagonal - Ref. Code 19, 20;
Prior Data - Database and MARB filing for 1987 rates.

Massachusetts Private Passenger Automobile
Incurred Losses by Layer
for Bodily Injury Coverage

$50,001 - $100,000

Accident Year	1st	2nd	3rd	4th	5th
1977	2,712,775	3,584,248	4,344,381	4,805,391	5,533,783
1978	2,033,535	3,707,292	4,430,796	4,893,689	4,917,532
1979	4,017,800	5,732,664	6,546,534	7,323,086	7,593,165
1980	6,540,817	8,513,894	9,644,483	10,522,621	10,616,046
1981	9,066,375	11,295,091	13,479,031	13,969,067	14,360,597
1982	8,325,067	11,214,156	13,008,255	14,373,216	14,953,638
1983	9,622,349	12,913,200	15,260,716	16,514,873	
1984	9,414,597	14,176,539	16,483,396		
1985	12,357,243	16,752,334			
1986	14,130,123				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1977	1.3212	1.2121	1.1061	1.1516
1978	1.8231	1.1952	1.1045	1.0049
1979	1.4268	1.1420	1.1186	1.0369
1980	1.3017	1.1328	1.0911	1.0089
1981	1.2458	1.1934	1.0364	1.0280
1982	1.3470	1.1600	1.1049	1.0404
1983	1.3420	1.1818	1.0822	
1984	1.5058	1.1627		
1985	1.3557			
Weighted Average*	1.3782	1.1725	1.0775	1.0348

1st/5th Development Factor 1.8018

* Weights given in 1988 MARB, 101B-2, p.2.
Source: Latest diagonal - Ref. Code 19, 20;
Prior Data - Database and MARB filing for 1987 rates.

Massachusetts Private Passenger Automobile
Incurred Losses by Layer
for Bodily Injury Coverage

Layer Over $100,000

Accident Year	1st	2nd	3rd	4th	5th
1977	372,250	498,348	964,033	1,051,549	1,346,696
1978	228,775	302,401	349,156	1,250,018	350,604
1979	625,601	572,084	1,079,854	1,091,197	1,309,961
1980	1,288,132	1,175,105	1,692,203	1,460,399	2,081,903
1981	2,600,796	2,403,540	2,999,229	2,988,789	3,608,083
1982	2,681,208	2,594,275	3,206,552	4,096,441	4,224,167
1983	1,825,229	2,646,890	3,100,991	3,662,381	
1984	1,214,941	2,424,984	2,990,295		
1985	3,292,717	4,285,121			
1986	3,618,815				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1977	1.3387	1.9345	1.0908	1.2807
1978	1.3218	1.1546	3.5801	0.2805
1979	0.9145	1.8876	1.0105	1.2005
1980	0.9123	1.4400	0.8630	1.4256
1981	0.9242	1.2478	0.9965	1.2072
1982	0.9676	1.2360	1.2775	1.0312
1983	1.4502	1.1716	1.1810	
1984	1.9960	1.2331		
1985	1.3014			
Weighted Average*	1.4170	1.2191	1.1640	1.1112

1st/5th Development Factor 2.2344

* Weights given in 1988 MARB, 101B-2, p.2.
Source: Latest diagonal - Ref. Code 19, 20;
Prior Data - Database and MARB filing for 1987 rates.

Massachusetts Private Passenger Automobile
Incurred Losses for Bodily Injury Liability
Excess Limits

Accident Year	1st	2nd	3rd	4th	5th
1978	21,090,342	29,772,527	35,210,816	38,631,024	38,637,396
1979	30,240,870	39,826,347	45,823,212	49,180,133	50,553,401
1980	41,965,785	55,161,926	61,793,183	66,022,344	67,752,814
1981	53,249,975	65,143,747	75,291,311	79,342,914	81,917,322
1982	54,540,649	70,026,408	78,639,961	84,774,475	86,712,748
1983	57,986,759	78,752,334	92,761,211	98,724,135	
1984	61,853,587	86,159,330	99,294,975		
1985	74,404,463	98,816,428			
1986	76,848,221				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1978	1.4117	1.1827	1.0971	1.0002
1979	1.3170	1.1506	1.0733	1.0279
1980	1.3144	1.1202	1.0684	1.0262
1981	1.2234	1.1558	1.0538	1.0324
1982	1.2839	1.1230	1.0780	1.0229
1983	1.3581	1.1779	1.0643	
1984	1.3930	1.1525		
1985	1.3281			
Weighted Average*	1.3332	1.1535	1.0661	1.0272

1st/5th Development Factor 1.6841

*Weights given in 1988 MARB, 101B-2, p.2.
Source: Reference Code 21, loss 01, 11, 02, and 14, excess limits.

1988 Massachusetts Private Passenger Automobile
Bodily Injury Liability (A-1 and B)

Reallocation by Layer of Allocated Loss Adjustment Expense

(1) Layer	(2) Fitted Ratio**	(3) Difference in Ratios	(4) Cumulative Exposure #	(5) (3)x(4)x15,373,249 / sum ((3)x(4))
0	0.058 *	0.058	3,103,795.0	9,722,722
1	0.066	0.008	2,312,637.6	999,228
2	0.074	0.008	2,257,079.7	975,222
3	0.081	0.007	1,938,009.6	732,691
4	0.100	0.019	1,569,589.2	1,610,669
5	0.119	0.019	1,073,292.3	1,101,383
6	0.144	0.025	171,329.5	231,334

* Observed Ratio, 1988 AG 101A-3, Page 2, Column (4).
** See 1988 AG 101A-3, Page 2, Column (5).
\# 1988 AG 101A-4, Column (5).

1988 AG
101A-3
Page 2

1988 Massachusetts Private Passenger Automobile
Bodily Injury Liability (A-1 and B)

Allocated Loss Adjustment Expense vs. Basic Limits Losses
1986 Accident Year

(1) Per Person Policy Limit x (000's)	(2) Basic Limits Losses ($10K)	(3) ALAE	(4) Observed Ratio (3)/(2)	(5) Fitted Ratio*
10	78,153,111	4,503,444	0.058	
15	4,459,765	373,559	0.084	0.066
20	21,844,904	1,530,684	0.070	0.074
25	20,296,954	1,450,416	0.071	0.081
50	22,218,585	1,891,473	0.085	0.100
100	34,123,214	4,334,553	0.127	0.119
Over 100 (x = 250)	6,661,242	978,494	0.147	0.144

*Least Square Line: (excess limits) $-0.0082 + 0.0276 \ln(x)$

$R^2 = 0.861$

Source: Database Reference 20

1988 Massachusetts Private Passenger Automobile
Adjustment of Exposures to Include "All Other" Limits

(1) Layer	(2) Limit	(3) 1986 Earned Exposure *	(4) Adjustment to Include All Other**	(5) Adjusted Exposures
0	10/20	791,157.4		791,157.4
1	15/30	55,557.9		55,557.9
2	20/40	271,892.4		271,892.4
	20/50	47,177.7		47,177.7
3	25/50	291,756.7	55,868.3	347,625.0
	25/60	20,795.4		20,795.4
4	50/100	482,329.8	13,967.1	496,296.9
5	100/300	901,962.8		901,962.8
6	Over 100/300	171,329.5		171,329.5
	All Other	69,835.4		
	Total	3,103,795.0		3,103,795.0

* Data Base Reference 01
** 80% of All Other attributes to limits 25/50, the remainder to limits 50/100, following MARB methodology in previous years.

1988 Massachusetts Private Passenger Automobile
Calculation of Accident
Limit Discount by Layer

(1) j	(2) Limit Value bj	(3) Layer of Losses between bj-1 and bj •Bj #	(4) Cumulative Losses sum Bi (i=1 to j)	(5) Accident Limit Discount * (ALD)	(6) Adjusted Cumulative Losses ACBj = (4) x (5)	(7) ACBj - ACBj-1	(8) Implied Accident Limit Discount For Layer j ALDj = (7)/(3)
0	10	190,063,345	190,063,345	0.982	186,642,205	186,642,205	0.982
1	15	17,115,484	207,178,829	0.989	204,899,862	18,257,657	1.067
2	20	11,747,545	218,926,374	0.996	218,050,669	13,150,807	1.119
3	25	7,594,786	226,521,160	0.997	225,841,597	7,790,928	1.026
4	50	18,886,559	245,407,719	0.999	245,162,311	19,320,714	1.023
5	100	14,130,123	259,537,842	1.000	259,537,842	14,375,531	1.017
6	100+	3,618,815	263,156,657	1.000	263,156,657	3,618,815	1.000

From Schedule 101A-1, page 1, column (3).
* 1 - Accident Limit Discount Percentage from 1988 MARB 101A-4, Exhibit 1.
for j=2 and j=3, ALD = average of {1 - Accident Limit Discount Percentage} for corresponding Limit Value.

1988 AG
Schedule 101B

1988 Massachusetts Private Passenger Automobile
Summary of PDL Increased Limits Factors

Limit	1986 Exposure	Increased Limits Factor Indicated #	Increased Limits Factor Proposed +
10,000	373,431	1.064	1.064
15,000	83,138	1.073	1.073
25,000	592,948	1.077	1.077
35,000	359,589	1.077	1.077
50,000	1,006,172	1.078	1.078
100,000 and over	520,428	1.081	1.081
	2,935,706		

From 1988 AG 101B-1, page 1, column (11).
+ From 1988 AG 101B-1, page 1, column (12).

1988 Massachusetts Private Passenger Automobile
Development of Loss Pure Premium Increased Limits Factor
PDL

(1)	(2) Limit Value	(3) Layer of Losses Between bj-1 and bj	(4) Layer of Losses Between bj-1 and bj/f	(5) Portion of Losses to be Transferred out of Layer by Trending	(6) Exposures of Vehicles Insured for Limit bj	(7) Cumulative Exposures	(8) Adjusted Layer of Losses	(9) Layer Pure Premium	(10) Cumulative Layer Pure Premium	(11) Indicated Increase Limit Factor	(12) Proposed Loss Pure Premium Increased Limits Factors
j	bj	Bj	Xj	Tj	Ej	CEj	Aj	PPj	CPPj	Ij	-----
0	5,000	230,050,845	227,875,294	2,175,551	168,090	3,103,796	226,564,913	90.53	90.53	1.000	1.000
1	10,000	10,154,618	9,545,543	609,075	373,431	2,935,706	12,913,655	5.77	96.30	1.064	1.064
2	15,000	1,233,443	1,075,715	157,728	83,138	2,562,275	1,607,313	0.83	97.13	1.073	1.073
3	25,000	501,277	466,731	34,546	592,948	2,479,137	619,341	0.33	97.46	1.077	1.077
4	35,000	83,756	51,067	32,689	359,589	1,886,189	77,351	0.05	97.51	1.077	1.077
5	50,000	58,329	46,705	11,624	1,006,172	1,526,600	73,163	0.06	97.57	1.078	1.078
6	100,000 and over	87,739	87,739	0	520,428	520,428	91,702	0.25	97.82	1.081	1.081

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Data Sources and Formulae for Schedule 101B-1, Page 1

Col. (3): Data Base Reference 11

Col. (4): Data Base Reference 11

Col. (5): $T_j = B_j - X_j$

Col. (6): 101B-4

Col. (7): $\sum_{i=j}^{9} E_i$

Col. (8): $A_j = X_j + T_{j-1}\left(\frac{CE_j}{CE_{j-1}}\right)$

A_0 and A_1 also include adjustments calculated on 101B-1, page 3.

Col. (9): $PP_j = (((A_j \times LDF_j) + (ALAE_j \times LDF_0))/CE_j) \times f \times f_2 \times M$

Col. (10): $CPP_j = \sum_{i=0}^{j} PP_i$

Col. (11): $I_j = \frac{CPP_j}{PP_0}$

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Development of Loss Pure Premium Increases Limit Factor

PDL, Increased Limits
Notes

MODIFICATIONS INCLUDED IN THE DETERMINATION OF Aj IN COLUMN (8)

1. Allocated Loss Adjustment Expense (Data Base 09) Is included as follows :

Layer	Amount
0	2,019,010
1	0
2	0
3	0
4	0
5	0
6	0
Total	2,019,010

2. Losses in Layer 0 are modified to equal the basic limits loss pure premium for PDL:

A)	PDL loss and ALAE (1988 AG 100A-1, p.3) #	230,712,265
B)	Basic limits trend factor (1988 AG 100C-1)	1.074
C)	Trended basic limits losses - (A) x (B)	247,784,973
D)	Layer 0 loss from 101B Page 1 Column (4)	227,875,294
E)	Layer 0 ALAE from above	2,019,010
F)	Trend factor (f) (1988 AG 100C)	1.084
G)	Trended layer 0 [(D) + (E)] x f	249,205,426
H)	Adjustment to layer 0 after trend (C) - (G)	(1,420,453)
I)	Adjustment to layer 0 before trend (H)/f	(1,310,381)
J)	Adjustment to layer 1 before trend	1,310,381

FACTORS FOR COLUMN 9

Layer	f (cost trend)	f2 (frequency trend)	LDF	M *
0	1.084	1.000	1.1340	1.00
1	1.084	1.000	1.2109	1.00
2	1.084	1.000	1.2109	1.01
3	1.084	1.000	1.2109	1.01
4	1.084	1.000	1.2109	1.02
5	1.084	1.000	1.2109	1.02
6	1.084	1.000	1.2109	1.06

* 1988 MARB 101B-1, Page 2.
\# Includes adjustment for delinquent carrier.

Massachusetts Private Passenger Automobile
Excess Incurred Losses
for Property Damage Liability

Over $5000

Accident Year	1st	2nd	3rd	4th	5th
1980	3,876,565	3,588,699	3,115,895	3,072,640	3,173,479
1981	4,210,225	4,317,803	4,267,453	4,193,398	4,362,952
1982	4,540,589	4,589,165	4,821,097	4,902,487	4,956,790
1983	5,492,746	6,997,541	7,691,549	7,540,551	
1984	8,816,507	10,661,530	11,022,203		
1985	12,955,840	14,006,399			
1986	16,198,663				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1980	0.9257	0.8683	0.9861	1.0328
1981	1.0256	0.9883	0.9826	1.0404
1982	1.0107	1.0505	1.0169	1.0111
1983	1.2740	1.0992	0.9804	
1984	1.2093	1.0338		
1985	1.0811			
Weighted Average*	1.1356	1.0481	0.9931	1.0244

1st/5th Development Factor 1.2109

* Weights given in 1988 MARB, 101B-2, p.2.
Source: 1988 MARB, 101B-2, Page 1.

1988 Massachusetts Private Passenger Automobile
Selected Increased Limits Factors

U, Increased Limits

Limit	1986 Exposure	Increased Limits Factor Indicated #	Proposed +
15/30	43,763.5	2.438	2.44
20/40	190,573.0	2.777	2.76
20/50	45,936.2	2.777	2.80
25/50	161,397.3	3.052	3.03
25/60	51,523.0	3.052	3.07
All Other	5,711.0	3.052	3.24
	1,427.7	4.007	
50/100	221,611.0	4.007	4.01
100/300	435,462.4	5.284	5.28
250/500	54,006.1	9.108	9.11
500/1000	1,551.9	9.108	9.11
Total	1,212,963.1	4.230	4.23

From 1988 AG 101B-1, page 1, column (11).
+ From 1988 AG 101B-1, page 1, column (12).

1988 Massachusetts Private Passenger Automobile
Development of Loss Pure Premium Increased Limits Factor
Formulae explained elsewhere.
U

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Limit Value	Layer of Losses Between bj-1 and bj	Layer of Losses Between bj-1 and bj/f	Portion of Losses to be Transferred out of Layer Bj by Trending	Exposures of Vehicles Insured for Limit bj	Cumulative Exposures	Adjusted Layer of Losses	Layer Pure Premium	Cumulative Layer Pure Premium	Indicated Increased Limit Factor	Proposed Loss Pure Premium Increased Limits Factors
j	bj	Bj	Xj	Tj	Ej	CEj	Aj	PPj	CPPj	Ij	
0	10,000	36,292,958	34,548,826	1,744,132	1,890,832	3,103,795	28,427,446	19.82	19.82	1.000	1.000
1	15,000	3,100,597	2,543,863	556,734	43,764	1,212,963	11,588,098	28.50	48.32	2.438	2.438
2	20,000	2,445,830	1,856,746	589,084	236,509	1,169,199	2,633,880	6.72	55.04	2.777	2.777
3	25,000	1,693,930	1,158,496	535,434	218,631	932,690	1,705,127	5.45	60.49	3.052	3.052
4	50,000	4,560,259	4,038,526	521,733	223,039	714,059	4,530,161	18.92	79.41	4.007	4.007
5	100,000	4,224,954	3,760,061	464,893	435,462	491,020	4,166,647	25.31	104.72	5.284	5.284
6	above 100,000	1,358,827	1,358,827	0	55,558	55,558	1,412,007	75.81	180.53	9.108	9.108

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1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Data Sources and Formulae for Schedule 101C-1, Page 1

Col. (3): Data Base Reference 11

Col. (4): Data Base Reference 11

Col. (5): $T_j = B_j - X_j$

Col. (6): 101C-4

Col. (7): $\sum_{i=j}^{9} E_i$

Col. (8): $A_j = (ALD_j \times X_j) + (ALD_{j-1} \times T_{j-1} \left(\frac{CE_j}{CE_{j-1}} \right))$

A_0 and A_1 also include adjustments calculated on 101C-1, page 3.

Col. (9): $PP_j = (((A_j \times LDF_j) + (ALAE_j \times LDF_0))/CE_j) \times f \times f_2 \times M$

Col. (10): $CPP_j = \sum_{i=0}^{j} PP_i$

Col. (11): $I_j = \frac{CPP_j}{PP_0}$

1988 Massachusetts Private Passenger Automobile
Development of Loss Pure Premium Increased Limits Factor
U, Increased Limits
Notes

Modifications included in the determination of Aj in column (8).

1. Allocated Loss Adjustment Expense (Data Base 09) is included as follows:

Layer	Amount
0	2,277,512

2. Losses in Layer 0 should be modified to equal the basic limits loss pure premium for U:

A)	U loss and ALAE (1988 AG 100A, p.4)	29,979,446
B)	Basic limits trend factor (1988 AG 100C-1)	1.116
C)	Trended basic limits losses = (A) x (B)	33,457,062
D)	Layer 0 loss from 101C, Page 1, column 4	34,548,826
E)	Layer 0 ALAE from above	2,277,512
F)	Trend factor (f) (1988 AG 100C)	1.068
G)	Trended layer 0 ((D) + (E)) x f	39,330,529
H)	Adjustment to layer 0 after trend (C) - (G)	(5,873,467)
I)	Adjustment to layer 0 before trend (H)/f	(5,499,501)
J)	Basic Limits trend factor, prior to inclusion of losses trended into Coverage U from BI (See 1988 AG 100C-6, Page 1) (line (4) / (line (3a) + line (3c)))	1.020
K)	Trended basic limits losses, prior to inclusion of losses trended into Coverage U from BI (A) x (J)	30,579,035
L)	Adjustment to layer after trend (G) - (K)	8,751,494
M)	Adjustment to layer before trend (L)/f	8,194,283

Factors for column 9:

Layer	f (cost trend)	f2 (frequency trend)	LDF	ALD #	M *
0	1.068	1.000	1.8760	0.982	1.00
1	1.068	1.000	2.7928	1.071	1.00
2	1.068	1.000	2.7928	1.109	1.00
3	1.068	1.000	2.7928	1.022	1.00
4	1.068	1.000	2.7928	1.018	1.00
5	1.068	1.000	2.7928	1.011	1.00
6	1.068	1.000	2.7928	1.000	1.00

* 1988 MARB 101C-1, page 2.
# 1988 AG 101C-4.

Massachusetts Private Passenger Automobile
Excess Incurred Losses
for Uninsured Coverage

Over 10000/20000 Limits

Accident Year	1st	2nd	3rd	4th	5th
1980	1,009,357	1,426,970	2,354,661	2,495,109	2,409,499
1981	2,631,745	6,408,917	8,712,013	9,682,055	11,073,989
1982	5,370,219	9,767,024	13,025,516	17,169,233	17,764,336
1983	5,740,391	9,382,817	16,143,280	18,849,549	
1984	9,205,675	19,892,498	27,858,691		
1985	19,063,712	30,376,214			
1986	25,867,940				

Development Factors

Accident Year	1st/2nd	2nd/3rd	3rd/4th	4th/5th
1980	1.4137	1.6501	1.0596	0.9657
1981	2.4352	1.3594	1.1113	1.0347
1982	1.8187	1.3336	1.1676	
1983	1.6345	1.4005		
1985	1.5934			
Weighted Average*	1.7571	1.4144	1.1201	1.0033

1st/5th Development Factor 2.7928

* Weights given in 1988 MARB, 101B-2, p.2.
Source: 1988 MARB, 101C-2, Page 1.

1988 Massachusetts Private Passenger Automobile
Adjustment of Exposures to Include "All Other" Limits

Limit	Coverage U 1986 Exposures Exposures *	Adjustment to Include All Other**	Adjusted Exposures
10/20	1,890,831.9		1,890,831.9
15/30	43,763.5		43,763.5
20/40	190,573.0		190,573.0
20/50	45,936.2		45,936.2
25/50	161,397.3	5,711.0	167,108.3
25/60	51,523.0		51,523.0
50/100	221,611.0	1,427.7	223,038.7
100/300	435,462.4		435,462.4
250/500	54,006.1		54,006.1
500/1000	1,551.9		1,551.9
All Other	7,138.7		
Total	3,103,795.0		3,103,795.0

* Data Base Reference 01 and 02.
** 80% assigned to 25/50 limit, 20% assigned to 50/100 limit.

1988 Massachusetts Private Passenger Automobile
Calculation of Accident
Limit Discount by Layer

(1) j	(2) Limit Value bj	(3) Layer of Losses between bj-1 and bj Bj #	(4) Cumulative Losses sum Bi (i=1 to j)	(5) Accident Limit Discount * (ALD)	(6) Adjusted Cumulative Losses ACBj = (4) x (5)	(7) ACBj - ACBj-1	(8) Implied Accident Limit Discount For Layer j ALDj = (7)/(3)
0	10	36,292,958	36,292,958	0.982	35,639,685	35,639,685	0.982
1	15	3,100,597	39,393,555	0.989	38,960,226	3,320,541	1.071
2	20	2,445,830	41,839,385	0.996	41,672,027	2,711,801	1.109
3	25	1,693,930	43,533,315	0.997	43,402,715	1,730,688	1.022
4	50	4,560,259	48,093,574	0.999	48,045,480	4,642,765	1.018
5	100	4,224,954	52,318,528	1.000	52,318,528	4,273,048	1.011
6	100+	1,358,827	53,677,355	1.000	53,677,355	1,358,827	1.000

From Schedule 1988 AG 101C-1, page 1, column (3).
* 1 - Accident Limit Discount Percentage from 1988 MARB 101A-4, Exhibit 1.
for j=2 and j=3 ALD = average of {1 - Accident Limit Discount Percentage} for corresponding Limit Value.

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE

Summary of Bodily Injury Coverage Increased Limits Factors

Limit	1986 Exposures	Exposures Adjusted to include all others	Current Excess Factor	Proposed Excess Factor
10/20	791,157.4	791,157.4	0.00	0.00
15/30	55,557.9	55,557.9	0.21	0.24
20/40	271,892.4	271,892.4	0.36	0.36
20/50	47,177.7	47,177.7	0.41	0.40
25/50	291,756.7	347,625.0	0.49	0.47
25/60	20,795.4	20,795.4	0.54	0.51
50/100	482,329.8	496,296.9	0.84	0.81
100/300	901,962.8	901,962.8	1.23	1.18
250/500	165,072.7	171,329.5	2.13	1.79
500/1000	6,256.8		2.61	2.19 *
Other	69,835.4		0.56	0.55
Total - 10/20	2,312,637.6		0.9533	0.8998
Total	3,103,795.0			

* Proposed excess factor 500/1000 limit calculated as the product of proposed excess factor for 250/500 x current excess factor for 500/1000 divided by current excess factor for 250/500 or (1.79) * (2.61) / 2.130

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Summary of PDL Excess Limits Factors

Limit	1986 Earned Exposure	Current	Proposed Excess Factor
10,000	373,431	0.060	0.064
15,000	83,138	0.066	0.073
25,000	592,948	0.072	0.077
35,000	359,589	0.078	0.077
50,000	1,006,172	0.084	0.078
100,000 and over	520,428	0.090	0.081
	2,935,706		
Weighted average		0.0783	0.0763

1988 Massachusetts Private Passenger Automobile
Summary of Coverage U Increased Limits Factors

Limit	1986 Exposures	Current Excess Factor	Proposed Excess Factor
15/30	43,763.5	0.59	1.44
20/40	190,573.0	1.06	1.76
20/50	45,936.2	1.11	1.80
25/50	161,397.3	1.49	2.03
25/60	51,523.0	1.54	2.07
50/100	221,611.0	2.54	3.01
100/300	435,462.4	3.88	4.28
250/500	54,006.1	5.90	8.11
500/1000	1,551.9	9.35	8.11
Other	7,138.7	1.71	2.24
	1,212,963.1	2.6353	3.2258

1988 MASSACHUSETTS PRIVATE PASSENGER AUTOMOBILE
Correction of 1988 MARB Increased Limits Factor
for U Coverages*

Limit	1986 Exposures	Current Excess Factor	Proposed Excess Factor
15/30	43,763.5	0.59	0.87
20/40	190,573.0	1.06	1.56
20/50	45,936.2	1.11	1.60
25/50	161,397.3	1.49	2.22
25/60	51,523.0	1.54	2.26
50/100	221,611.0	2.54	3.75
100/300	435,462.4	3.88	5.66
250/500	54,006.1	5.90	8.00
500/1000	1,551.9	9.35	10.50
Other	7,138.7	1.71	2.54
	1,212,963.1	2.6353	3.8302

* Data from 1988 MARB Schedule 101E, Page 3